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Sequential Analysis of Design Processes Performed by Design Experts and College Students in Infographic Design

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SEQUENTIAL ANALYSIS OF DESIGN PROCESSES PERFORMED BY
DESIGN EXPERTS AND COLLEGE STUDENTS IN INFOGRAPHIC DESIGN

By

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To my Mom and Dad for their unconditional love.

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# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................................ vii
LIST OF FIGURES ...................................................................................................................... viii
ABSTRACT .................................................................................................................................... x

1. INTRODUCTION ....................................................................................................................... 1
   The Study’s Context ................................................................................................................... 1
   Problem Statement ................................................................................................................... 3
   Purpose of the Study ................................................................................................................... 4
   Significance and Implications ..................................................................................................... 5

2. LITERATURE REVIEW ............................................................................................................ 6
   Visual Communication ............................................................................................................... 6
   Infographics .............................................................................................................................. 12
   Infographic Design Model .................................................................................................... 19
   Conclusion ................................................................................................................................ 26

3. METHOD .................................................................................................................................. 28
   Research Design ....................................................................................................................... 28
   Sampling and Inclusion Criteria ............................................................................................... 29
   Participants ............................................................................................................................... 30
   Instruments ............................................................................................................................... 30
   Procedures ................................................................................................................................. 37
   Data Sources ............................................................................................................................. 38
   Data Analysis ........................................................................................................................... 39
   Trustworthiness ......................................................................................................................... 45

4. RESULTS .................................................................................................................................. 47
   Pre-Knowledge Equivalence .................................................................................................... 47
   Infographics Ratings ............................................................................................................... 47
   Visual Design Processes ......................................................................................................... 52
   Visual Design Strategies ........................................................................................................ 59
   Visual Design Model ................................................................................................................ 70
5. DISCUSSION.................................................................................................................................. 74
   Main Findings.................................................................................................................................. 74
   Supplemental Findings .................................................................................................................... 80
   Instructional Implications ............................................................................................................... 82
   Limitations...................................................................................................................................... 83
   Directions for Future Research....................................................................................................... 84

APPENDIX A. MULTIMEDIA LEARNING MATERIAL............................................................... 86
APPENDIX B. MULTIPLE-CHOICE ASSESSMENT ................................................................. 94
APPENDIX C. RESEARCH SCRIPT ......................................................................................... 98
APPENDIX D. ADAPTED VERSION OF THE INFOGRAPHIC DESIGN RUBRIC ............ 101
APPENDIX E. IRB APPROVAL NOTICE .............................................................................. 104
APPENDIX F. CONSENT FORM .............................................................................................. 106
APPENDIX G. PERMISSION TO USE FIGURES ..................................................................... 110

REFERENCES................................................................................................................................. 112
BIOGRAPHICAL SKETCH............................................................................................................. 121
LIST OF TABLES

Table 1. Examples of visual design criteria in the Infographic Design Rubric (Nuhoğlu Kibar & Akkoyunlu, 2017, p. 38-39) ............................................................................ 22

Table 2. Examples of multiple-choice items and feedback .................................................................................. 32

Table 3. Demographic questions included in the pre-made script .................................................................. 33

Table 4. Initial list of design actions and examples ......................................................................................... 40

Table 5. Descriptive statistics of infographic overall standardized scores .................................................. 48

Table 6. Average score and standard deviation per rubric item ..................................................................... 51

Table 7. Visual design processes, design actions, and percentage of time spent in each process .. 54
LIST OF FIGURES

Figure 1. Cognitive Theory of Multimedia Learning (adapted from Mayer (2017, p. 405) ..........14
Figure 2. Infographic Design Model (adapted from Nuhoğlu Kibar & Akkoyunlu (2015, p. 243)) 20
Figure 3. Infographic Design Process (adapted from Nuhoğlu Kibar & Akkoyunlu (2015, p. 244)) 21
Figure 4. Design tool interface ...................................................................................................... 31
Figure 5. High-rated infographic and scores (Kuba & Jeong, 2023) ............................................ 35
Figure 6. Average-rated infographic and scores (Kuba & Jeong, 2023)...................................... 36
Figure 7. Low-rated infographic and scores (Kuba & Jeong, 2023) ............................................. 36
Figure 8. Plot of temporal event sequences (Kuba & Jeong, 2023) .............................................. 42
Figure 9. Transitional frequency, transitional probability, and z-scores matrices of six themes generated in DAT software (Kuba & Jeong, 2023) ........................................................................ 44
Figure 10. Transitional state diagrams (Kuba & Jeong, 2023) ...................................................... 44
Figure 11. Whisker plot and scatterplot for the standardized total scores ................................. 48
Figure 12. High-rated infographic (score = 181.85) ................................................................. 49
Figure 13. High-rated infographic (score = 169.85) ................................................................. 49
Figure 14. Low-rated infographic (score = 116.85) ................................................................. 50
Figure 15. Low-rated infographic (score = 88.85) ................................................................. 50
Figure 16. Temporal event sequence plot ...................................................................................... 56
Figure 17. Transitional state diagrams ......................................................................................... 58
Figure 18. Elements of a grid ........................................................................................................ 62
Figure 19. Grid in a high-rated infographic ............................................................................... 62
Figure 20. Lack of grid in a low-rated infographic ..................................................................... 63
Figure 21. Vertical guidelines created to add paddings in the textboxes and baselines created to align elements across the groups .................................................................................. 66
Figure 22. Examples of a widow and text rags ...............................................................67

Figure 23. Three options created by a high performer ..................................................69

Figure 24. Infographic Visual Design Model ...............................................................70
ABSTRACT

This study examines the visual design processes and strategies used by graphic design experts and non-design college students when applying visual design principles to compose an infographic. The focus is on the visual design stage, often reported as challenging for adult and young students (e.g., Fragou & Papadopoulou, 2020; O'Mahony et al., 2019). The goal is to identify differences in the strategies utilized to produce higher and lower-quality infographics scored across 17 design criteria.

This study employs a collective case study design, in which participants were asked to create an appealing and readable infographic and think aloud as they performed the task. Each participant was presented with identical ready-to-use text, icons, and shapes on a given topic and used the design tool to complete the task. The participants consisted of 5 graphic design experts recruited through snowball sampling and 5 non-design college students recruited through typical sampling. All sessions were recorded and transcribed for data analysis.

Results revealed six visual design processes: (1) create structure and grid, (2) establish visual hierarchy, (3) define visual rules, (4) replicate visual rules, (5) test and adjust, and (6) validate and revise. Also, high-rated infographics were produced using a more systematic design process, starting with working on the structure and grid and establishing a visual hierarchy, and moving on to define and replicate visual rules, followed by testing and adjustments, and validation. Moreover, the study identified many design strategies from the comparative analysis between high and low-performers, such as: (1) using a breadth-first approach by laying out the elements over a grid and working on visual hierarchy before working on details, (2) placing related content near each other and less related content spaced apart to spatially organize and structure the content, (3) using up to two font styles and opting for legible fonts over decorative fonts, (4) testing various colors, fonts, and graphics while preserving the overall structure and hierarchy, and (5) stepping back to validate the overall design and making final adjustments based on the optical weight. These target processes and strategies were encapsulated into a five-stage Infographic Visual Design Model.
CHAPTER 1
INTRODUCTION

The Study’s Context

New technologies have made the world increasingly visual, making visual literacy a crucial 21st Century skill. Visual literacy refers to the ability to use, interpret, create, and evaluate visual messages, comprising three areas: visual thinking, visual learning, and visual communication (ACRL, 2011; Seels, 1994). Visual thinking is an internal process concerning visualization through images and mental pictures of sensory experiences, and visual learning refers to acquiring knowledge from visuals. Visual communication, the focus of this study, is an external process involving the creation and use of visuals to express ideas and communicate meaning (Seels, 1994). Visual communication has become a critical part of knowledge creation as digital technologies have allowed virtually everyone to create and share visual messages that may affect their lives and the wider public (OECD, 2017; PISA, 2019). One type of visual message production suggested by PISA (2019) in their framework to assess visual communication skills is infographic design, subject under investigation in this study.

Moreover, the 21st Century Literacy Summit advocated policy revisions to improve students’ 21st Century skills, such as incorporating visual literacy in curriculums and preparing teachers with strong visual communication skills (New Media Consortium, 2005). However, higher education still lags in adopting visual communication into their programs more than fifteen years later (Fragou & Papadopoulou, 2020). In addition, the shape of education has changed in recent years as concerns about COVID-19 have moved many classes and educators into a distance learning format, making the production of visuals a crucial skill. The worldwide e-learning sector is projected to pass $450 billion by the year 2026, and 33 percent of post-secondary school administrators have decided to offer both online and in-person class options once universities and colleges have resumed normal operations (Global Industry Analysts, 2021; Venable, 2022). To keep up with the changes, individuals must be well-versed with visual communication skills for their particular areas, as they will be required to interpret, use, and produce information presented visually in both their academic and professional work (Ariga et al., 2016). The role of education is to equip students with visual communication skills, enabling them to adapt to a continuously and rapidly changing world (PISA, 2019).
However, such skills have been identified as a "missing piece" in academic programs, and research indicates that academics and students are weak in visual communication skills (Ervine, 2016; Fragou & Papadopoulou, 2020; Sosa, 2009). For example, O’Mahony et al. (2019) looked at individual sessions between scientists and a graphic designer and discovered that many of the visuals, such as infographics, created by scientists for publications were unsatisfactory and needed significant improvements, such as changing colors and creating proper alignment and layout. Nuhoğlu Kibar & Akkoyunlu (2018) found that, when designing infographics, 7th-graders felt comfortable with generating content but struggled with the visual design process, particularly the tasks that involved drafting a layout and creating visuals. Furthermore, Chen et al. (2014b) reported that graduate students from various engineering programs could not produce visuals to explain their ideas and often gained visual design skills from peers in a haphazard way without a clear framework. In sum, both young and adults are lacking in the ability to create high-quality visuals.

Despite the modest incorporation of visual communication into academic curriculums, the number of researchers testing visual design principles and encouraging visual communication skills is continuously expanding (e.g., Bratslavsky et al.; 2019, Ulger, 2019). For instance, Yeh and Cheng (2010) compared critical analysis skills of visual communication products between pre-service teachers who received \( n = 39 \) and did not receive lessons \( n = 49 \) on visual design principles. The lessons included the principles of contrast, repetition, alignment, and proximity, based on *The Non-Designer’s Design Book* (Williams, 2008). A repeated-measures ANOVA contrasting pretest and posttest scores revealed that the teachers who received the instruction demonstrated a higher ability to critically evaluate the soundness of the product’s visual design and understand the meaning conveyed in the visuals. Moreover, Bratslavsky et al. (2019) tested two design tasks to promote visual communication skills: a task with clear directions regarding content, layout, and tools and an ambiguous task, in which students could choose the content, layout, and tools. Results showed that students in the ambiguous group enjoyed creative freedom and sought to self-learn design software and recalled more essential components of visual communication, such as design principles and visual composition. In addition, students reported feeling more proud of their design process and aware of how visual messages are produced.

Given the value and broad application of visual communication across many disciplines, researchers have advocated for including visual communication courses in educational settings to
encourage effective communication through visual representation and purposeful design choices (Bratslavsky et al., 2019; Güney, 2019). However, the integration, adoption, and teaching of visual communication skills have not progressed at the appropriate pace (Ervine, 2016).

**Problem Statement**

In general, researchers agree that producing visual communication products helps students interpret visuals, as well as develop a better understanding of how information works (e.g., Bratslavsky et al., 2019; PISA, 2019). Infographics, which challenge students to represent data visually in different ways, are one kind of visual production proposed by PISA (2019) in their framework for assessing visual communication. Infographics combine text and graphics and are frequently used to convey data and knowledge utilizing visualization, text descriptions, and visuals (Lan et al., 2021). For example, infographics help explain relationships between concepts and procedures, present the content of a lesson, communicate processes, and summarize important information (Ibrahim & Alamro, 2021). However, the design process for producing effective infographics (i.e., infographics that provide clear and meaningful information while also being aesthetically pleasing) is complex, requiring multiple criteria to be applied simultaneously related to content creation, visual design, and typography. For instance, one case study (Yuruk et al., 2019) reported that infographic creation-based training improved graduate students’ academic achievement, metacognitive abilities, and retention. On the other hand, in terms of visual design criteria and principles, the quality of the infographics did not improve. A study with college students (Fragou & Papadopoulou, 2020) found comparable results, as over half of the students' infographics were inadequate, lacked visual structure, and students required frequent assistance in applying design principles such as consistency, emphasis, and balance.

While creating infographics can help improve learning, more research is needed to develop approaches to help students better learn how to apply visual design principles to produce high-quality infographics that deliver instructional messages (Lan et al., 2021). Moreover, while few studies have produced useful tips for designing visual communication products (e.g., Pole & Parashar, 2020; Tomita, 2017), these tips can be challenging to apply without a validated visual design model for systematically integrating the tips. Visual design models at present lack specific strategies and guidelines for applying multiple design principles to produce high-quality visuals. Some formulated models to aid visual design focus on artistic compositions (Lu et al., 2016) and
creative processes (Groenendijk et al., 2018) rather than the process of applying visual design principles. One model proposed as a process model to support students in creating infographics was presented by Nuhoğlu Kibar and Akkoyunlu (2015). Their model was specifically developed to help and teach students how to create and organize content to design infographics. When testing the model with K12 students, students struggled with the visual design process and needed further lectures on design principles (Nuhoğlu Kibar & Akkoyunlu, 2018). Similar results were found by Fragou and Papadopoulou (2020) when testing the model in higher education, as most of the produced infographics were inconsistent in the application of design principles.

Researchers (e.g., Brumberger, 2019; Richey & Klein, 2009) argued that studies comparing performances between experts and novices are critical to determining actual design processes utilized and understanding the different strategies used by participants of varying levels of expertise. Likewise, this study investigates the design process used in applying design principles by design experts and students with no prior course in design to identify unique strategies and processes in higher-quality designs. These strategies will be incorporated into a procedural model to assist students in designing visuals, especially when applying design principles. The findings from a pilot study conducted with design experts and instructional designers (all of whom have in the past completed a design course and worked with visuals for learning) will be used to interpret the findings in this study to achieve deeper insights into the design processes performed by individuals across different levels of expertise. Studies showed that students lack the ability to apply design principles (e.g., Fragou & Papadopoulou, 2020), do not have a clear framework for producing visuals (Chen et al., 2014b), and current models lack procedural guidance in the visual design stage (e.g., Nuhoğlu Kibar and Akkoyunlu, 2015).

**Purpose of the Study**

This study examines the visual design processes and strategies used by graphic design experts and non-design college students when applying visual design principles to compose an infographic. The focus is on the application of various design principles in combination since studies have shown that students lack the ability apply the principles to create visuals (e.g., Fragou & Papadopoulou, 2020; Nuhoğlu Kibar & Akkoyunlu, 2018). The goal is to formulate a visual design model to guide students in the application of design principles based on the processes and distinctive techniques employed to produce high-quality infographics by
comparing and differentiating the processes used by participants who generate higher versus lower quality infographics. The infographics are scored by two graphic designer experts using an adapted version of the Infographic Design Rubric (Nuhoğlu Kibar & Akkoyunlu, 2017). The resulting model aims to give insight into the processes that may be prescribed to assist students in using visual design principles to generate higher-quality infographics, and as a result, to assist students in improving their ability to represent information visually.

Thus, this study addresses the following research questions:

1. What visual design processes are used by graphic design experts and non-design college students to generate higher and lower quality infographics?

2. What unique strategies are used in higher-quality infographics?

3. What unique strategies are used in lower-quality infographics?

4. What is the resulting visual design model based on observations and comparisons of the processes employed by graphic design experts and non-design college students to generate higher versus lower quality infographics?

**Significance and Implications**

The overarching goal is to enhance students’ visual communication skills, equipping them to adapt to an increasingly digital world, where the creation and share of visuals dominate online environments. More specifically, this research seeks to expand the Infographic Design Model (Nuhoğlu Kibar & Akkoyunlu, 2015), particularly the visual design stage, often reported as challenging for adult and young students (e.g., Fragou & Papadopoulou, 2020; O'Mahony et al., 2019). Results of the study may propose directions for future research, such as testing the model across different populations, fields, and types of visuals, and creating adaptive tools to assist non-design students through the design process. Moreover, the resulting model may provide practical guidance on designing effective visuals to boost students' and teachers’ visual communication skills for their particular field.
CHAPTER 2
LITERATURE REVIEW
Visual Communication

The Context of Visual Literacy and Visual Communication

In summary, researchers assert that visual literacy is one of the most imperative 21st-century skills since students are increasingly exposed to visuals, needing skills for effective communication and combatting the potential of manipulation and misinformation in media and images (Catanzaro & Collin, 2021). However, to this date, terms such as visual communication, visual literacy, and even graphic design are so broad that it is difficult to use them precisely to describe specific functions (Avgerinou & Pettersson, 2020). The term visual literacy gained substantial momentum in the United States during the late 1960s due to the increase concern about the impact of television on children. Various groups focused on making people more visual literate were formed, such as the Action for Children’s Television and the International Visual Literacy Association (IVLA) (Avgerinou & Pettersson, 2011). The IVLA was established in 1969 during the first National Conference on Visual Literacy that gathered teachers and professionals from diverse fields, such as language, art, psychology, and linguistics (Pett, 1989). The IVLA has been the most influential group concerned the study and practice of visual literacy and visual communication (Avgerinou & Pettersson, 2020).

However, even after 50 years of the IVLA establishment, there is no consensus about the definition of visual literacy and visual communication (Brumberger, 2019). Researchers argue that the lack of consensus is because visual literacy covers a broad spectrum of disciplines, theories, and applications, and visual communication is also multidisciplinary and multidimensional, making different group of scholars have their own view of visual literacy and visual communication (Avgerinou & Pettersson, 2020). For example, the Association for Educational Communication and Technology adopted Debes’ (1969) definition of visual literacy, referring to a group of competencies that enable an individual to discriminate and interpret visual products and use these competencies to communicate with others. The Association of College and Research Libraries (ARCL) proposed a new definition of visual literacy in 2011, referring to a “set of abilities that enables an individual to effectively find, interpret, evaluate, use, and create images and visual media.” Other researchers (e.g., Güney, 2019) have used Seels’ (1994) definition that presents a distinction between visual literacy and visual communication, stating
that the latter is a subdimension of the former. According to Seels, visual literacy is a continuum process that encompasses the ability to think visually through mental pictures of sensory experiences (i.e., internal process), learn from visuals (i.e., internal and external process), and communicate visually by creating and transmitting visual messages to an individual’s environment (i.e., external process).

Thus, to identify common points of convergence about visual literacy definitions, Avgerinou and Pettersson (2011) conducted a literature review gathering studies from three decades. Some of the convergence points stated that (1) the main focus of visual literacy is intentional communication in an instructional context, (2) visual literacy skills are learnable, teachable, and capable of development, (3) visual literacy skills concern the ability to read, interpret, encode, and create visuals and think visually, and (4) visual communication, visual thinking, and visual learning are constructs of visual literacy. Building upon their study, Kedra (2018) reviewed eleven definitions of visual literacy in the literature to identify specific abilities that makes an individual visual literate. In terms of visual communication and creation, the abilities included communicate creatively with others, combine visuals and verbal for intentional communication, create visual media, develop messages using symbols, and produce visual materials in a diverse media.

In this study, I adopt Seels’ (1994) definition of visual literacy that presents a relationship between visual literacy and visual communication and use Avgerinou and Pettersson’s (2011) convergence points about the characteristics of visual literacy. With this in mind, I investigate ways to improve intentional multimodal communication in instructional settings by identifying specific skills and processes used to create more effective visuals to express ideas and communicate meaning (i.e., visual communication). Next, I review some visual communication initiatives in higher education followed by a contextualization of research on visual communication.

**Visual Communication in Higher Education**

Learning visual communication (also referred to as visual design) is not only for design students. For instance, scientists may produce visuals to model hypotheses, detect important patterns in data, and convey ideas to the scientific community and the general public (Arneson & Offerdahl, 2018). As an example, Cheng et al. (2017) redesigned graphics from published studies
using validated design principles and gathered feedback from 50 participants who regularly read scientific journals. Results from participants’ self-reported survey showed that the redesigned graphics improved readers’ understanding of the papers and enhanced their initial perception of the paper, such as believing the papers with redesigned graphics were more interesting and with more rigor to science. Similarly, visual design skills are integral for students in educational technology programs as they are often required to produce learning tools such as infographics and slide presentations to convey instructional messages (Ervine, 2016). For instance, Sosa (2009) redesigned an undergraduate instructional technology course for pre-service teachers and included visual communication guidelines (e.g., how to combine colors) related to visual design principles. Results revealed the after-instruction products were more usable and more professional looking than the pre-instruction products. Also, based on the researcher’s observation, students exhibited more pride in their work as they exchanged their URL portfolio and added it to their resumes.

Moreover, educators cannot assume that students already possess the skills needed to be visually literate, and the increase propagation of visuals does not imply that students comprehended what is being conveyed (Avgerinou, 2009). The ability to interpret and create visuals does not develop unless the skills are taught, supported, and integrated into the curriculum (Abas, 2019; Catanzaro & Collin, 2021). As Brumberger and Northcut (2016) pointed out, there is a need to develop visual communication skills especially in higher education both within school and in out-of-school contexts. Further, researchers argue that visual design programs for non-design students should differ from novice design students since the former usually lack confidence in their sense of design, often do not know where to begin or how to apply design principles, and also might produce visuals focused on instructional messages rather than artistic achievement (Ariga et al., 2016; Blummer, 2015; Ervine, 2016). For those reasons, researchers have increased their attention to teaching visual communication skills to non-design students. Nonetheless, the integration of visual communication courses into higher education programs have not progressed at the necessary rate (Ervine, 2016).

To illustrate, a literature review (Blummer, 2015) on visual design in higher education revealed different educational strategies used to improve visual communication skills, such as scaffolds (e.g., taxonomies, tutorials, and blogs), assignments and activities, (e.g., creating graphic representations of data, charts, and concept maps), lectures on visual design principles,
and research to identify optimal instructional practices. For instance, Saterbak et al. (2018) presented lectures on data representation to bioengineering students and proposed activities to foster visual communication skills, such as developing graphs and figures to represent experimental data and composing a slide presentation. Results from convergence analysis showed that after the intervention, students’ ability to self-evaluate their work was significantly more aligned with the instructor’s evaluation and students’ work substantially improved based on the instructor’s ratings.

Moreover, Abas (2019) developed an activity to foster visual analysis. The activity was organized in three 50-minute sessions and included strategies such as encouraging students to search visual materials and prompting them to interpret the meanings in photographs. Upon completion, students reported that they became more aware of how image creators use certain elements to communicate meanings. Additionally, Min (2019) proposed an activity in which students had to transform a written paper into a brochure using visuals and colors and composing a layout. Results showed that students struggled to convey the content in a more visual form, but through the process of reconceptualization and reconstruction based on peer feedback, they learned the significance of integrating visuals into writing and how information can be manipulated by visual images. Similar results were found in studies integrating activities on information presented visually in business (Gadelshina et al., 2019), accounting (Schwartz, 2020), and education (Loerts & Belcher, 2019).

The above studies back up Avgerinou and Pettersson’s (2011) assertion that visual literacy skills are learnable, teachable, and capable of development and that such skills need to be explicitly taught (Abas, 2019). Likewise, this study aims to contribute to the continuing development of visual communication skills in higher education. More specifically, I intend to develop a visual design model based on the observations and comparison of design processes from graphic design experts and non-design students. The proposed model aims to be a procedural model for creating infographics regarding the use of layout, colors, shapes, and typography and may offer practical advice on producing visual messages for both learning and teaching visual communication skills. Lastly, this study may advance research on visual communication, a topic that intersects many disciplines, allowing its research to contribute to many areas and practices, both inside academia and in society. Although research on visual literacy and visual communication has been evolving in the past three decades, more research is
needed to map the topic and questions, create a research agenda, refine research methods, and better define the field (Brumberger, 2019).

**Visual Communication in Research**

While pedagogical case studies on teaching visual communication, such as those discussed earlier, are increasing in number, research on visual communication is still in its infancy (Kedra, 2018). For example, Brumberger (2019) analyzed articles published in the *Journal of Visual Literacy* (organized by the IVLA group) from 1981 through 2017 to investigate the evolution of research on visual literacy regarding research topics and questions. Results indicated that only 27% of the articles were considered research articles (i.e., included specific research questions and hypotheses). Most articles were pedagogical case studies, such as describing an assignment or activity, and conceptual, mainly trying to understand and define visual literacy. Besides, researchers (e.g., Brumberger, 2019; Kedra, 2018) have advocated for an end to the debate over the ideal way to define visual literacy, arguing that we should focus on translating theory into real learning and teaching objectives.

Nevertheless, the amount of research published on visual literacy has grown in the last two decades. While the number of articles was held somewhat constant between 1980 and 2000 (mean of 18 articles per year), the number almost doubled after 2001 (mean of 33 articles per year). However, during the first two decades, researchers focused on visual thinking (e.g., recalling visual stimuli) and visual learning (e.g., testing different types of visuals for instruction); and little to no attention was given to visual communication and the processes of designing visuals. Only in the last decade has the emphasis on visual communication started to grow, including research questions on the quality of graphics, perceived aesthetic value, and creation of visuals (Brumberger, 2019).

Specifically for visual communication, researchers argue that there are many unsolved problems. For example, Brumberger (2019) notes that, from a disciplinary view, there is little scholarship that investigates effective research methods on visual communication. According to the author, developing reliable research methods is crucial for any field as scholars can select the best approaches to address research questions. Also, given the many disciplines that contribute to visual literacy and visual communication study, it is probable that there are multiple research methods to advance knowledge in visual communication (Brumberger, 2014). In addition, many
studies on visual communication rely on lists of dos and don’ts based on past practices (e.g., Kuba et al., 2021; Pole & Parashar, 2020; Tomita, 2017), being prescriptive guidelines or tips that lack a foundation for the sound and consistent decision-making in visual communication (Brumberger, 2014; Kedra, 2018). Thus, from a pedagogy view, there is a need to investigate ways to teach students to think about design decisions without presenting a list of items to check off (Brumberger, 2014). Furthermore, Brumberger (2019) advocates that research into ‘expert’ and ‘novice’ visual communication behaviors can contribute to this gap by helping refine the operational definition of visual communication and identifying how well a student has mastered specific visual communication skills.

In line with Brumberger's (2019) and Kedra's (2015) proposition, this study investigates the visual design process performed by experts and novices to identify specific strategies employed in high-quality visuals. While the comparison of the design processes based on observations might not yield specifics facets to assess visual communication skills, it can help researchers derive a model encompassing the effective strategies in design processes. Such a model can help students think more deeply about visual communication, encouraging them to make contextualized design decisions instead of following prescriptive guidelines such as checking off items of dos and don'ts. Prescriptive guidelines are usually oversimplifications that hardly account for variations, which can impact meaning (Brumberger, 2014). For these reasons, in terms of pedagogy, research on visual communication should go beyond prescriptions and case studies describing activities and focus on research methods and practices to teach and assess learning objectives and academic outcomes (Brumberger, 2019; Kedra, 2018).

As an example, Brumberger (2019) mentions exploring approaches to help students strengthen their ability to interpret and create information using visual materials, such as infographics. Infographics were identified as a trending topic in the past decade (Brumberger, 2019) as researchers have explored their effectiveness as learning tools (e.g., Ibrahem & Alamro, 2021) and the creation of infographics for improving visual communication skills (e.g., Nuhoğlu Kibar & Akkoyunlu, 2017). Inline, this study focused on the visual design process in composing infographics, such as creating layout and alignment when applying visual design principles. The value of infographics for both learning and visual communication skills is discussed next.
**Infographics**

**Introduction to Infographics**

Infographics, short for information graphics, are considered visual tools that use images, text descriptions, embellishments, and visualizations to convey data and knowledge, informing users in general (Lan et al., 2021; Ozdamli & Ozdal, 2018). Infographics take various shapes and forms, such as presented in a static, animated, or interactive format, used in printed or digital format, and composed of data graphics, maps, and diagrams (Otten et al., 2015). Some examples include visual storytelling, flow chart, timeline, interactive data visualization (statistical-based), compare and contrast, how-to (process-oriented), and ‘did-you-know?’ (Siricharoen & Siricharoen, 2015). Also, infographics are characterized by several benefits including shortening explicatory text, dismissing the need for high-cost software or programming skills, and simplifying scientific facts using visualization (Afify, 2018). Additionally, the design of infographics might combine principles from diverse fields, such as education, usability, graphic design, and statistics to stress important data in an accessible and appealing format (Otten et al., 2015). For example, from an educational view, infographics make complex information more visible and clearer for learners to structure and organize what is being communicated (Alqudah et al., 2019; Baglama et al., 2017). At the same time, principles from usability and graphic design make data more accessible, understandable, and manageable, helping the audience perceive and interpret detailed and complex structures easily and rapidly (Ozdamli & Ozdal, 2018).

As a result, infographics have been widely used in different areas such as journalism and marketing to attract and persuade audiences (Lan et al., 2021), healthcare to educate patients about surgery recovery and minimize uncertainties (Lonsdale et al., 2020), and education to improve learning outcomes (Alqudah et al., 2019). For instance, a study (Kunze, et al., 2021) compared social media attention based on Altimetric Attention Score (AAS) between article abstracts using infographics and original research articles on the same topic, all published in the *Arthroscopy* journal. The AAS mean difference was significantly higher for all infographics, with a mean of 29.75 ($SD = 32.84$) and 5.75 ($SD = 8.90$) for the research articles. In addition, infographics had significantly more Twitter mentions (100% vs. 70.8%) and Facebook mentions (75% vs. 6.2%) compared with original articles.

In terms of educational settings, Alqudah et al. (2019) compared posttest scores on perception of instruction and semiotics from 138 college students who studied lessons with
infographics versus traditional instruction (i.e., using a textbook, data show, and whiteboard). They found that the infographic group outperformed those in the traditional group in the posttest, and results from a self-reported survey revealed that students who received lessons with infographics perceived the lessons to be less difficult. Ibrahem and Alamro (2021) compared the effectiveness of static versus animated infographics on 80 college students’ computer skills and achievement motivation. Results from the teacher’s observation scale revealed that both forms of infographics were more effective in engaging students in learning than traditional instructions, and there was no significant difference between the infographic forms on computer skills. In another study, Alsaadoun (2021) compared comprehension of instructional design concepts between college students who received lessons with the aid of infographics ($n = 33$) and lessons on the same topic using traditional instruction without infographics ($n = 31$). Results from T-tests showed that pretests scores were not significant different, but posttest scores were significant higher in the infographic group ($Mean = 2.82$, $SD = 0.47$) than in the control group ($Mean = 1.94$, $SD = 0.44$). Comparable results were found in studies examining the effects of using infographics on affective responses (Lan et al., 2021), achievement motivation (e.g., Ibrahem & Alamro, 2021), and collaborative learning (Nuhoğlu-Kibar et al., 2019).

Therefore, infographics incorporate visual organization and structure to convey relationships, describe how parts of a whole interact, and communicate abstract ideas that would otherwise require a lengthy narrative (Dunlap & Lowenthal, 2016). While there are many types of infographics (e.g., diagrams and data visualization), one common characteristic of all infographics is the combination of words and pictures to convey information. This feature echoes the multimedia principle, supported by the Cognitive Theory of Multimedia Learning (Mayer, 2017), discussed next.

**Cognitive Load View of Infographics**

According to the Cognitive Theory of Multimedia Learning (Mayer, 2017), cognitive science (Paivio, 1986), and Cognitive Load Theory (Sweller et al., 2011), people have two separate information processing channels for visual and verbal information: auditory sensory memory and visual sensory memory (Paivio, 1986). These processing channels are resource-limited and can hold only a few elements in each channel in working memory for a fleeting time (Mayer, 2017). For example, when the learner views an infographic, they can hold only a few
portions of the infographic in the visual channel of working memory at a time rather than a
precise copy of the material. Similarly, when the learner hears a narration, they can hold only a
few words in the verbal channel of working memory at a time rather than a verbatim recording
(Mayer, 2014). Due to this limited capacity, multimedia instructional materials, such as
infographics, must present the content without overloading the visual and auditory channels in
working memory to help learners actively engage in cognitive processing by constructing a
coherent mental representation of their experiences (Moreno & Mayer, 2002). These active
cognitive processes, called active learning, comprise attending to relevant incoming information,
organizing it into a coherent structure, and integrating it with other knowledge (Mayer, 2014).
Active learning (Figure 1) is an iterative process and can occur as follow:

Figure 1. Cognitive Theory of Multimedia Learning (adapted from Mayer (2017, p. 405)

1. Attention is directed to some of the information in sensory memory.
2. Information is carried to working memory and is actively processed to be held in working
memory.
3. Arriving verbal information is mentally organized into a coherent verbal representation
and the arriving visual information into a coherent pictorial representation.
4. Relevant prior knowledge is activated from long-term memory and transfer it into
working memory to be integrated with the verbal and pictorial representations, which are
also integrated with each other.
5. The learning outcome is formed in working memory to be stored in long-term memory.
As shown in Figure 1, although portions of a multimedia message enter the information system via one channel (i.e., auditory or visual), learners can mentally convert the information to be also represented in the other channel. For example, the learner starts processing a picture of a beach in the visual channel and then mentally converts the picture into sounds (e.g., ocean wave sounds), that are processed via the auditory channel. Likewise, the learner starts processing a narration in the auditory channel as it is presented to the ears and also connects the narration to a mental image, processed through the visual channel (Mayer, 2014). Drawing on this process, the multimedia principle states that people learn better from words and pictures than words alone since learners can better construct verbal and visual mental representations in working memory and make connections between them (Mayer, 2017). In contrast, when only words are presented, learners can build verbal representation but are less likely to build and connect to a visual representation (Mayer, 2014; Moreno & Mayer, 2002). According to Mayer (2017), words can be in spoken (e.g., narration) or printed form (e.g., onscreen text), and pictures can be static such as diagrams, maps, and photos, or dynamics, such as videos and animations.

Hence, multimedia messages help learners maximize working memory resources available and engage in more generative cognitive processing, which refers to deep learning and making sense of the materials, enabling retention and transfer (Mayer, 2014; Sweller et al., 2011). For instance, researchers showed that learners who studied lessons designed with the multimedia principle (i.e., multiple-representation conditions) outperformed those who studied lessons with words alone on recall tasks (Glaser & Schwan, 2015), transfer (Moreno & Ortegano-Layne, 2008), and retention tests (Moreno & Mayer, 2002). Additionally, the multimedia principle yielded a large effect size of \( d = 1.67 \) among five experimental studies comparing materials designed with and without the principle (Mayer, 2017).

Likewise, infographics intend to make instructional messages easier to understand, helping learners attend to relevant information, structure it, and integrate it with other knowledge structures by simplifying complex information using visuals that otherwise would require a prolonged description (Baglama et al., 2017; Dunlap & Lowenthal, 2016). Thus, the combination of words and pictures in infographics guides learners to hold both visual and verbal representations to make more sense of the materials and engage in more meaningful learning (Moreno & Mayer, 2002). Although cognitive load and learning outcomes are not examined in this study, the findings presented above help point to the broader ramifications of ways to help
students create higher quality infographics that combine words and pictures, which in turn, can help students better learn the content that is presented in their infographics. Thus, given the significance of infographics, researchers have investigated ways to aid educators and learners improve their skills and ability to develop effective infographics (e.g., Nuhoğlu Kibar & Akkoyunlu, 2017; Fragou & Papadopoulou, 2020), presented next.

**Infographic Design and Visual Communication Skills**

PISA (2019) suggests using infographics to measure visual communication skills regarding the ability to generate diverse ideas (e.g., asking learners to represent data in different ways). When learners create an infographic, they can engage in open visual design task, learn digital tools, and develop visual design ideas according to the scenario and stimuli specified in the task (e.g., designing an infographic for a particular audience or purpose) (PISA, 2019). However, creating an infographic is not an effortless work as infographic design often comprises numerical data and visual representations that, if not well-designed, can deliver misleading information (Otten et al., 2015). Thus, research on infographic design is increasing (Brumberger, 2019) as scholars started to explore the creation of infographics for improving visual communication skills (e.g., Nuhoğlu Kibar & Akkoyunlu, 2017).

For example, Dunlap and Lowenthal (2016) examined the top 20 most liked infographics on an infographic sharing website to identify common characteristics and propose design recommendations for students and teachers to design infographics. Examples of recommendations included keeping an infographic to one page, focusing only on one learning objective, using relevant and simple images, and avoiding details that serve as distractions. Moreover, a study (Afify, 2018) investigated the use of infographics in developing college students’ skills in designing visuals for learning. Students were divided into two conditions and studied lessons on visual design using either static or animated infographics. During the experiment, students were required to produce visuals such as educational posters, infographics, and presentations. Researchers scored the visual materials using ten criteria such as, clarity of the message and contrast between visual elements. Results comparing pretest and posttest revealed that all students improved their ability to produce visuals and recognize design principles, but students who studied lessons with static infographics outperformed those in the animated group.
Other researchers have proposed infographic design activities to enhance students’ understanding of a particular topic while learning visual communication skills. For instance, Stoerger (2018) redesigned a final informational technology project and asked students to create infographics about a topic of their interest. The project required students to rely predominantly on images instead of text to convey their message to an external audience. The researcher reported that students began with the mindset that they were not artistically capable, did not possess visual design experiences, and experienced creative anxiety and fear of failure. Still, through an iterative design process, all students were able to complete their infographics and develop more visual communication skills. Additionally, results from observations showed that students improved their understanding of their topic as they had to analyze and summarize complex information to compose their infographics. Also, students demonstrated a sense of pride in their creations, shared their work beyond the classroom, started to consider career opportunities in the tech field, and increased their self-competence in creativity and interest in learning new technologies.

Similarly, in another infographic design study (VanderMolen & Spivey, 2017), college students learned visual communication skills such as layout, color, and composition and reported enjoying the process of creating infographics. More specifically, students were undergraduates enrolled in a health economics course (n = 54) and were asked to research a topic and synthesize information to present their findings in an infographic. All students received lessons on best practices for creating infographics. Results from self-reported survey revealed that 88% believed that producing infographics helped them retain information more effectively than writing a paper and was more fun and engaging. In addition, most students stated that the visual communication skills to develop infographics would be valuable in the future. According to the authors, former students pointed out that they were required to create an infographic in their new jobs, and thus learning infographics in a course was helpful. All in all, the authors argued that infographic design opens opportunities for active learning to enhance student engagement, retention, and communication skills.

In Chaudhury’s study (2021), infographic design activities were designed and implemented to help students learn how to use new visual communication tools. A total of 184 undergraduate students enrolled in a marketing course learned (largely self-directed learning) a data visualization tool to produce infographics in a semester-long project. Students worked
collaboratively in groups of five and tested various infographics software platforms. Results showed that 95% of the students learned two or more infographics tools, developed the confidence to learn new technological tools and could apply their knowledge in designing infographics in other course projects such as finance and management.

As Bratslavsky et al. (2019) pointed out, creating visual representations help learners better understand of how information, communication, and design work in together. At the same time, developing visual representations like infographics demands a meticulous process because infographics create high-sensory impact to deliver information that must be factual and not misleading (VanderMolen & Spivey, 2017). For instance, a recent study (Oliveira & Cook, 2017) revealed that when selecting images to compose visuals for learning, most students chose images without critically interpreting them, introducing the potential for miscommunication. The researchers argued that students needed to be encouraged to examine the implicit and explicit meanings conveyed in images and evaluate aspects of visual representations. In their discussion, the researchers advised teachers to present information using different types of visuals to identify misconceptions and avoid miscommunication.

In conclusion, visual communication skills have become vital in recent years as the omnipresence of digital imaging and design software allows nearly everyone to produce visuals that serve the lives of individuals and the wider public (PISA, 2019). Still, the design process of developing visuals such as infographics is complex, requiring the designer to simultaneously apply numerous criteria regarding content production, visual design, usability, and expressiveness (Lan et al., 2021). To identify and differentiate infographic design processes that produce higher versus lower quality infographics, this study relies on the use of specific criteria to evaluate the quality of the infographics produced by the participants in this study. The above studies shed light on aspects for evaluating the quality of participant-produced infographics, such as creating a layout, color, and composition (VanderMolen & Spivey, 2017); contrasting visual elements (Afify, 2018); and avoiding details that serve as distractions (Dunlap & Lowenthal, 2016). In addition, this study uses the Infographic Design Model (Nuhoğlu Kibar & Akkoyunlu, 2015) – one designed to help students produce infographics – as a framework for analyzing and corroborating the design processes and behaviors observed in this study.
Infographic Design Model

Nuhoğlu Kibar and Akkoyunlu (2015) developed the Infographic Design Model (IDM) to aid as a conceptual framework for producing effective infographics. The IDM identifies the skills needed to design infographics defined in three main dimensions: (1) **content generation**: developing and organizing the content; (2) **visual design**: using visual design principles to create a visual composition; and (3) **digital design**: the ability to use design software and tools (Figure 2). The focus of this study is on the visual design dimension, which includes two sub-dimensions. The *big picture* sub-dimension refers to the relationships between elements within an infographic regarding specific design principles (e.g., proximity and contrast). The *design component* sub-dimension refers to design decisions (e.g., choosing colors and graphics) based on the application of design principles.

The model was built using design-based research and in collaboration with science and technology, visual arts, and information technology teachers (Nuhoğlu Kibar & Akkoyunlu, 2015). Also, the model was grounded around Generative Learning Theory – a theory that views learning as an act of integrating new experiences with existing knowledge structures using active processes that can be physical, cognitive, or both (Fiorella & Mayer, 2015). The researchers validated the model with 27 students and their teachers over three cycles to get feedback on the model usage (Nuhoğlu Kibar & Akkoyunlu, 2018). The student feedback was used to help improve the model by identifying the areas where students needed more guidance and support in the infographic design process (Figure 3). In the study, teachers responded positively to the model, reporting that students understood the subject matter better as a result of having to search for and create their content, learning how to find and use visuals, and enjoying the work in digital environments. To further validate the model, 42 students participated in a quasi-experimental study, 21 in class A as the treatment group who designed an infographic following the model and 21 in class B as the control. All students completed a pretest, posttest, and retention collected using 13 multiple-choice items. The findings showed that using this design model to help students create their infographic helped the students make gains on retention test scores and infographic design scores, suggesting that producing higher-quality infographics can lead to higher learning-retention.
In line with the IDM dimensions, Nuhoğlu Kibar and Akkoyunlu (2015) proposed a four-stage process to guide teachers in helping students produce infographics: content preparation, lectures on creating infographics, content and draft generation, and design generation (Figure 3). The authors noted that, during the design process, teachers should provide constant feedback to students. In content preparation, teachers start with lectures on the content according to the curriculum. Next, teachers may provide lessons on designing infographics, such as introducing different types of infographics, asking students to analyze the relationship between information components, and encouraging students to examine layouts, typography, images, and colors. Afterward, students start generating content and preparing a draft of the infographic. In that stage, students need to have a good understanding of the content to visualize the information effectively and possess knowledge of digital tools to produce the drafts (Nuhoğlu Kibar & Akkoyunlu, 2015). According to the authors, the content and draft generation concern both the content generation and visual design dimensions and is the most critical stage as students must research and synthesize the information, determine relationships between information components, and sketch layout, titles, and short descriptions. Lastly, the design generation is the longest stage and is of greatest concern – a stage where design software and tools are used to compose appealing infographics based on the application of design principles.
To assess the students’ infographics in reference to the model’s dimensions (i.e., content generation and visual design), Nuhoğlu Kibar and Akkoyunlu (2015) created and tested the Infographic Design Rubric (IDR). The rubric supports teachers in formative assessment in helping students create infographics and indicates the quality level of the infographics.

![Infographic Design Process](adapted from Nuhoğlu Kibar & Akkoyunlu (2015, p. 244)]

**Infographic Design Rubric**

Nuhoğlu Kibar & Akkoyunlu (2017) developed the Infographic Design Rubric to evaluate students’ understanding of the content generation and visual design dimensions and observe the infographic design process. The IDR encompasses two sets of criteria – one on the content generation and the other on the visual design dimensions, – using a 4-level performance quality description (from unacceptable to exemplary). The content generation comprises of 11 criteria concerning how well the information is organized. For example, the rubric evaluates if the infographic includes a main heading that is intriguing and is descriptive of the presented content and if the presented information groups correspond to the content and reflects the semantic structure. The visual design dimension is divided into two parts corresponding to the big picture and design components sub-dimensions. The criteria concerning the big picture sub-dimension evaluates the overall design regarding the relationship of the infographic elements in accordance with design principles (e.g., whether the elements form a visual hierarchy and whether emphasis is applied to highlight important information). In contrast, the criteria on the design component sub-dimension assess the infographic elements in more detail, such as design decisions on fonts size and color combination. Table 1 shows examples of criteria concerning the visual design dimension.
Table 1. Examples of visual design criteria in the Infographic Design Rubric (Nuhoğlu Kibar & Akkoyunlu, 2017, p. 38-39)

<table>
<thead>
<tr>
<th>Criterium</th>
<th>Unacceptable (1)</th>
<th>Needs work (2)</th>
<th>Competent (3)</th>
<th>Exemplary (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual hierarchy</td>
<td>No visual hierarchy between the components is present or the hierarchy formed causes confusion</td>
<td>Components form a certain visual hierarchy</td>
<td>Components form a visual hierarchy consistent with the semantic grouping of information</td>
<td>Components form a visual hierarchy consistent with the semantic grouping and significance of the information</td>
</tr>
<tr>
<td>Emphasis</td>
<td>No emphasis is made and a focal point is not present</td>
<td>Fundamental portions of the information within the context are highlighted</td>
<td>Fundamental information within the context is highlighted and a focal point is created</td>
<td>Fundamental information within the context is highlighted and the focal point is created based on the main message</td>
</tr>
<tr>
<td>Font size</td>
<td>Font size is not legible.</td>
<td>Font size is large enough to read, but the variety of font sizes has a negative impact on readability.</td>
<td>Font size is large enough to read, and the variety of font sizes has a positive impact on readability.</td>
<td>Font size is large enough to read, and different font sizes have been used corresponding to the content.</td>
</tr>
<tr>
<td>Color harmony</td>
<td>The colors clash with each other and form a complicated structure.</td>
<td>The colors are harmonious but are too distractive.</td>
<td>The colors make up a harmonious palette, and diversity is obtained through a selection of different color tones.</td>
<td>The color palette of harmonious colors is congruent with the content, and diversity is obtained through a selection of different color notes.</td>
</tr>
</tbody>
</table>

The rubric was developed in an iterative design, including five design cycles. In the first cycle, the researchers drafted the criteria based on the specific tasks related to designing infographics (e.g., defining titles and applying background colors). To ensure validity, the researchers consulted with three instructional design experts in the next cycle and reviewed the rubric based on feedback received. In the next cycles, the researchers tested the rubric to account for reliability. First, 46 pre-service teachers used the rubric to evaluate five infographic examples. Results showed that all five intraclass correlations were statistically significant and the mean ICC value was 0.77 (min = 0.61 and max = 0.84), with 95% CI. Afterward, each teacher produced one infographic, and two instructional designers and the researcher used the rubric to evaluate the infographics. The intraclass correlations was significant with an ICC(3,3) = 0.97, using a 95% CI. Lastly, the researchers conducted another round of testing with K-12 and pre-
service teachers. The participants evaluated the same five infographic examples in addition to the previously produced infographics. The intraclass correlations from 68 assessment was again significant, with ICC(3, 43) = .94 for K-12 teachers and ICC(3, 25) = .92 for pre-service teachers, both using 95% CI.

In this study, I use the Infographic Design Model as a conceptual framework. More specifically, this study focuses on the visual design dimension, concerning both sub-dimensions (i.e., big picture and design component) because many studies report that the visual design stage in developing infographics has been found to be the most challenging for both young and adult learners (e.g., Fragou & Papadopoulou, 2020; Yuruk et al., 2019). Thus, this study attempts to control the content generation by providing identical text for all participants when designing the infographic in order to provide a task that reveal the visual design processes used by the participants in this study (see chapter 3 for more details). Additionally, this study uses an adapted version of the Infographic Design Rubric to evaluate the quality of the infographics, scored by two design experts and the researcher. What follows is a summary of findings from studies that have applied the Infographic Design Model and/or the Infographic Design Rubric.

**Infographic Design Model Testing**

Nuhoğlu Kibar and Akkoyunlu (2018) tested the Infographic Design Model with 7th grade students and observed their reactions to using the model in the design process. All students completed an infographic that was scored with the Infographic Design Rubric and responded to reflection forms to report what they thought they could and could not do well when designing the infographic. In addition, teachers participated in focus group interviews to share their opinions on the infographic design process. Results regarding the quality of the infographics based on the IDR revealed that the visual design generation dimension was lower (Mean = 2.22) than the content generation dimension (Mean = 3.33), especially on the design component sub-dimension related to colors and visuals (Mean = 2.65). Additionally, students stated that they felt more comfortable with content generation and preparation but struggled with the design generation, especially the tasks that concerned drafting a layout, producing visuals, and selecting colors. Also, students reported that the visual design generation dimension made the infographic design processes more difficult. Likewise, teachers affirmed that students had no difficulty in content generation, but experienced difficulties in composing layout, applying design principles, and
determining colors and visuals. Based on these results, the researchers conducted a second cycle of testing with another group of 7th graders, including more lessons on the visual design dimensions. With the help of a Visual Arts Teacher, students received more feedback and guidance on the visual design process. Results showed that students scored better on the visual design dimension ($\text{Mean} = 3.26$) and slightly higher on the content generation ($\text{Mean} = 3.48$) than the first group. The Visual Arts Teacher argued that more lessons on color information and creation of visuals are crucial to help students improve their abilities in the visual design domain.

Researchers Fragou and Papadopoulou (2020) found comparable results in a study with 24 university-level students. Students spent two weeks to produce their infographics and received no lecture on infographic design. The infographics were scored by two researchers, a tutor, and the module coordinator using the IDR. Results revealed that students performed satisfactorily in the content generation as over half of the infographics were either competent or exemplary in 7 out of 8 criteria, such as creating a main heading compatible with the main message (79%), including the key concepts (62%), organizing information into relevant groups (58%), and including examples to support the content (83%). In contrast, regarding the visual design dimension, most infographics were deficient and required improvements, resulting in infographics that lacked visual organization. In the big picture sub-dimension, 62% of the infographics were unacceptable or needed work in creating emphasis, 50% in consistency, 62% in balance, and 67% in creating integrity. In the design component sub-dimension, most infographics were unacceptable or needed work in choosing colors for visibility (67%), background color (58%), font type (50%), font size (54%), text justification (71%), and color combination (58%). These results corroborate Nuhoglu Kibar and Akkoyunlu’s findings (2018) given that both young and adult students performed competently in the content generation but lacked ability in the visual design dimension. For instance, Fragou and Papadopoulou (2020) exemplified that criterium in which students performed well in content generation (e.g., writing exemplifications) was not well implemented in the design stage (e.g., students tried to include too much text, harming the harmony of presentation).

A study (Nuhoglu Kibar & Akkoyunlu, 2017) used three cycles of infographic design tasks with groups of 4 students (15-16 years old), and the results revealed that students performed below competent in the content generation ($\text{Mean} = 2.65$), and even lower in the big picture sub-dimension ($\text{Mean} = 2.54$) and in use of colors and visuals ($\text{Mean} = 2.52$) in the first
cycle. However, with additional guidance focused on writing concise titles and short descriptions, creating layout, deciding on colors, and drawing or finding icons, the infographic scores improved by the end of the third cycle with a new mean of 3.31 for content generation and 3.57 for the big-picture and 3.38 for colors and visuals. Still, some criteria related to the design component sub-dimension was still low (i.e., choosing font size, font case, and line spacing) at the end of the third cycle.

Lastly, a pilot study (Kuba & Jeong, 2023) was conducted using both the model and rubric. Participants included 5 graphic design experts (Male = 3, Female = 2) and 5 instructional designers (Male = 2, Female = 3) recruited through network connections. All participants confirmed having taken classes related to visual design, learned about visual design principles, and designed visuals such as presentations and infographics in their jobs. Participants were asked to design an infographic and think aloud as they completed the task. With a focus on the visual design dimension, the participants were provided identical text and icons to control for any difference in the content generation dimension. The participants were instructed to use the same design tool (i.e., jMap; Jeong, 2020b) to control for differences in the digital design dimension. All sessions were video-recorded and the infographics were scored using the Infographic Design Rubric by two additional graphic design experts and the principal researcher. Participants with scores close to one SD above the mean were classified as high performers, those with scores one SD or more below the mean were identified as low performers, and those with scores near the mean as average performers. The high performers were graphic design experts with more than 10 years of experience, and the average performers were instructional designers with 3 to 6 years of experience. The low performers included two instructional designers and one graphic designer with 5, 10, and 12 years of experience, respectively.

The results revealed some differences in processes performed by high- versus low-performers. For example, the sequential analysis revealed that visual design processes used to produce the high-rated infographics were generally more structured, beginning with work on the structure, then visual hierarchy, followed by work on details such as colors and graphics. On the other hand, the processes used to create the low-rated infographics were the least structured given that work on choosing fonts-colors-graphics was widely distributed throughout the design task. Furthermore, analysis from the think-aloud protocol revealed that high-performers decided on a scheme to present one unit (i.e., one topic of the infographic), then moved on to iteratively
replicate the scheme for the remaining units/topics. In contrast, low performers showed little tendency to build an overarching visual scheme. Instead, they showed the tendency to make distinctive design decisions across different units (e.g., one with text and graphic elements and another with text fading), resulting in inconsistent designs.

Furthermore, results also showed similarities across all participants. For instance, all designers used font size to create a visual hierarchy such as increasing the font sizes of titles and subtitles in relation to the text. Also, all participants applied a bold style to highlight important information. The similarities might be due to the fact that all participants had taken visual design classes and were familiar with design principles. For example, instructional designers were familiar with the multimedia principles (Mayer, 2017) such as the signaling principle that suggests using bolded letters to emphasize keywords or sentences.

Given that visual communication skills are critical for all areas (Ariga et al., 2016; PISA, 2019) and students in higher education lack such skills (Ervine, 2016; Fragou & Papadopoulou, 2020; Brumberger & Northcut 2016), this study builds on the pilot study by replicating the research methods (detailed in Chapter 3) and expanding the participants to non-design college students with no prior course work in visual design. This study aims to explore the different strategies in design processes between design experts and non-design college students to identify the approaches that low-performers might need further guidance, identify strategies that can be taught, and ultimately improve visual communication skills in higher education.

**Conclusion**

Altogether, the prior studies show that (1) visual literacy mainly focus on intentional communication in instructional contexts, (2) young and adult students lack proficiency in performing the visual design process to produce higher-quality infographics, (3) current process models (e.g., Groenendijk et al., 2018; Lu et al., 2016; Nuhoğlu Kibar & Akkoyunlu, 2015) lack specific guidance and processes on the visual design stage for composing visuals for learning (4) visual design skills are learnable and teachable as affirmed by Avgerinou and Pettersson (2011), and (5) visual design skills need to be explicitly taught, echoing Abas (2019). For those reasons, this study aims to expand the Infographic Design Model by focusing on the visual design dimension (reported as one of the most challenging processes for students) and by investigating visual communication skills and processes used by students in higher education with no prior
design knowledge. The comparison in design processes between design experts and non-design students may give insights into the best strategies and processes for producing high-quality infographics. Such strategies and processes will be encapsulated in a process model – a model that can ultimately be used and referenced by teachers to help them guide students through the process of designing infographics and the visual design cycle.
CHAPTER 3

METHOD

Research Design

This study employs a collective case study design to examine how graphic design experts and non-design college students perform the visual design process when applying visual design principles. A visual design process refers to a series of actions performed in visual composition, such as constructing layout, creating alignment, and selecting colors and fonts (Kuba & Jeong, 2023). A case study is a strategy of inquiry where a researcher explores an in-depth phenomenon, such as a process consisting of a series of steps or several individuals or activities, based on extensive data collection (Creswell, 2018; Shelden et al., 2010). A collective case study is a type of case study design that refers to investigating, describing, and comparing multiple cases to provide insight into an issue or phenomenon (Creswell & Poth, 2018). Examining and comparing multiple cases allow researchers to detect processes and outcomes across all cases, enabling deeper understanding through more robust descriptions and explanations (Shelden et al., 2010). As a result, the goal of this study is to identify differences in the strategies used by experts versus non-design college students to develop higher (including lower) quality infographics scored across 17 design criteria.

The questions addressed in this study are:

1. What visual design processes are used by graphic design experts and non-design college students to generate higher and lower quality infographics?
2. What unique strategies are used in higher-quality infographics?
3. What unique strategies are in lower-quality infographics?
4. What is the resulting visual design model based on observations and comparisons of the processes employed by graphic design experts and non-design college students to generate higher versus lower quality infographics?

The remaining content of this chapter describes the participants, design task, instruments, procedures, data source, data analysis, and trustworthiness strategies.
Sampling and Inclusion Criteria

According to Creswell (2018), qualitative case studies are conducted using only a limited number of cases so that researchers can direct more time and resources to examine each case in greater detail to acquire a more in-depth understanding of the issue or phenomenon. Nielsen (2000) suggests conducting qualitative case studies with five participants as he found that, after the fifth participant, the researcher often observes the same findings without uncovering new information. The point when researchers recognize that they have identified the major themes and no new input surfaces is called saturation (Creswell & Poth, 2018). As a result, five graphic design experts and five non-design college students are the participants in this study, with more participants added to this study if saturation is not achieved.

In case studies, the researcher can employ purposeful sampling to intentionally choose representative cases for inclusion to achieve an understanding of the central phenomenon and to achieve some level of generalizability in the research findings (Creswell, 2018). This study employs two purposeful sampling techniques: snowball and typical sampling. Snowball sampling is used in this study to recruit graphic design experts, relying on the researcher’s network of connections to invite participants to the study and to ask the potential participants to recommend other individuals. To participate in the study, the graphic design experts: (1) hold a graphic design-related degree (e.g., industrial design and digital design), (2) have at least ten years of work experience, (3) speak English or Brazilian Portuguese (i.e., the languages spoken by the researcher), and (4) have produced visuals composed of images and text in specific mediums such as magazines, infographics, and posters (not mediums like video, 3D modeling, and graphic illustrations alone).

Typical sampling is used to recruit participants to generate findings that are representative of a typical population (Creswell, 2018). Using this method to recruit non-design college students, the students participating in this study: (1) are enrolled in a higher education institution at the time of study, (2) are pursuing a major unrelated to arts or graphic design (e.g., finances and computer sciences); (3) have not taken any visual design course, and (4) speak English or Brazilian Portuguese. The criteria for exclusion from participation include students in any Arts majors and those with cognitive deficits or identified as special needs.
Participants

The participants in this case study consisted of 5 design experts (Male = 3, Female = 2) and 5 non-design college students (Male = 2, Female = 3). The average age for the designers was 33 (min = 30, max = 36, SD = 2.24), and the average years of work experience were 11 (min = 10, max = 13, SD = 1.22). The designers were currently working in Brazil as graphic designers (n = 3), UX designers (n = 1), or product designers (n = 1). They all hold a bachelor’s degree in visual communication (n = 4) or product design (n = 1). Common design artifacts produced by the designers included infographics, illustrations, books and magazines, branding, websites, videos, and social media materials. The average age for non-design college students was 29.2 (min = 24, max = 35, SD = 3.96). They were enrolled in the following graduate programs: computer sciences (n = 2), electrical engineering (n = 2), and educational technology (n = 1). All graduate students reported not having taken any visual design class or other related course.

Instruments

Design Task

The design task in this study was developed to provide participants the opportunity to focus on the visual design dimension outline in the Infographic Design Model (Nuhoğlu Kibar & Akkoyunlu, 2015). Participants in this study are asked to create an appealing and readable infographic on the computer using visual design principles and think aloud as they performed the task. The design task requires the participants to use given on-screen text and icons (based on Lu et al., 2016) to create their visual composition and are presented with and encouraged to apply the CRAP visual design principles of contrast, repetition, alignment, and proximity (Williams, 2008). All participants receive the same content to compose their infographics to eliminate the possible influence of individual differences in content generation skills (one of the dimensions in the IDM) and are provided with the same design tool to control for any difference in the digital design dimension. The content consists of a total of four informational units (i.e., information on each of the four CRAP visual design principles) and is presented and explained to participants before the design task (discussed next). The screen canvas is fixed and sized at 1280 x 720 pixels so that all participants use precisely the same amount of space to compose and organize the text and icons (see Figure 4). Participants are given as much time and are permitted to edit the infographic as many times as they want until they are satisfied with their work.
In the specific tool (more details below) used by the participants, the participants can perform the following actions: (1) format the text (e.g., change fonts, styles, and colors) but cannot edit the text (e.g., change words); (2) create and combine shapes to construct new design elements but cannot place external images (e.g., an image pulled from the internet); and (3) apply basic effects (e.g., shadow and transparency) commonly found in presentation tools (e.g., PowerPoint) but cannot apply advanced effects such as texture and blur.

In a prior study (Kuba & Jeong, 2023), this task was tested with one instructional design graduate student to gather feedback on the clarity of the instructions. Based on the feedback received, a 5-minute introductory video was created that explained the design task, stressed the need to incorporate all the given text and icons, and demonstrated some of the formatting options. Also, the CRAP principles were added to the right side of the canvas to help participants remember the goals they are to attempt to achieve upon completion of their infographic (Figure 4). Finally, the one-on-one interview script was revised to include question prompts to motivate and remind participants to think aloud as they perform the design task. In the prior study, all ten participants understood the task and had no issues using the design tool.

![Design tool interface](image)

Figure 4. Design tool interface
Multimedia Learning Material and Assessment

To ensure all participants understand the content they are using to compose the infographic, the researcher provides multimedia learning materials (presented in a PDF on the computer screen) on the CRAP principles (Appendix A), explaining the definition of the principles and showing examples of how to apply each principle. Then, participants complete a multiple-choice assessment of 12 items (Appendix B) to confirm they learned the content – 3 items to test each of the four visual design concepts of contrast, repetition, alignment, and proximity. After completing the assessment, each participant receive feedback on each item identifying the correct answer and explaining why it is correct (see examples in Table 2). The researcher gives the participants the chance to retake the assessment after reading the feedback, and their final score is the mean of the two scores.

Table 2. Examples of multiple-choice items and feedback

<table>
<thead>
<tr>
<th>Item</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the scenarios below follow the Alignment principle?</td>
<td>Answer: B</td>
</tr>
<tr>
<td>a) Placing elements arbitrarily in the design.</td>
<td>Drawing lines to line up elements in the design follows the alignment principle.</td>
</tr>
<tr>
<td>b) Drawing lines to line up elements in the design.</td>
<td>Nothing should be placed on the page arbitrarily. All elements should have some visual connection with another element. We should avoid too many combinations of text alignment.</td>
</tr>
<tr>
<td>c) Combining various text alignments in the design.</td>
<td></td>
</tr>
<tr>
<td>d) Avoiding visual connections between elements in the design.</td>
<td></td>
</tr>
<tr>
<td>Which of the scenarios below follow the Repetition principle?</td>
<td>Answer: C</td>
</tr>
<tr>
<td>a) Using different colors, styles, and sizes for the headings.</td>
<td>Using the same color, style, and size for the headings. Elements that share similar characteristics are perceived as related (i.e., all headings are related as they have the same function and hierarchy).</td>
</tr>
<tr>
<td>b) Using the same color, but different style and size for the headings.</td>
<td></td>
</tr>
<tr>
<td>c) Using the same color, style, and size for the headings.</td>
<td></td>
</tr>
<tr>
<td>d) Using similar colors, styles, and sizes for the headings.</td>
<td></td>
</tr>
</tbody>
</table>

In the design and development of the instruments, the researcher conducted a cognitive interview with a representative participant from the population to pilot test the items and increase validity, readability, clarity, and understanding of the meaning. The interviewee read the learning material, completed the assessment, and was asked to restate each assessment question in his own words and identify the items that raised any doubts or questions. The researcher revised the
items based on the feedback received. Next, a graphic design expert revised both the learning material and assessment to validate them for accuracy and clarity. Finally, the researcher conducted a pilot test with five non-design college students. Students reported that the presentation was well-designed, the content was easy to understand, and had no issues responding to the assessment (all students answered nearly to all items correctly).

**Script**

The participants are read a script (Appendix C) based on a template developed by Steve Krug (2014) that includes the study’s purpose and think-aloud instructions. It begins with a brief explanation of the study’s goal followed by the think-aloud directions: “As you do the design task, I’m going to ask you as much as possible to try to think out loud: to say what you’re looking at, what you’re trying to do, and what you’re thinking.” Afterward, the researcher ask participants to read the presentation and complete the assessment. Next, the research requests permission to start recording the audio and video of the session and asks seven demographic questions (Table 3). The script ends with a few additional instructions: “Finally, I’m also going to ask you to do the task without using external resources. We’ll learn a lot more about how people create visual compositions that way. If you don’t like your first trial, you can edit as many times as you want until you are satisfied with your work.” The script includes question prompts to encourage participants to think aloud (e.g., “How do you feel about your work at this point?”).

**Table 3. Demographic questions included in the pre-made script**

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your educational background?</td>
</tr>
<tr>
<td>What is your current occupation?</td>
</tr>
<tr>
<td>How many years of work experience do you have?</td>
</tr>
<tr>
<td>Have you taken any visual design class or related class?</td>
</tr>
<tr>
<td>Have you worked with visual design before? For how long?</td>
</tr>
<tr>
<td>Can you give me examples of projects that you have to apply visual design skills?</td>
</tr>
<tr>
<td>If you don’t mind me asking and it is okay if you don’t want to answer, how old are you?</td>
</tr>
</tbody>
</table>
**Introductory Video**

Participants receive a link to watch an online 5-minute video (Kuba, 2020). The video shows the given components (i.e., text and icons), describes the canvas size, and explains the design task. The video also demonstrates how to turn on and off a grid, format text (e.g., applying bold, changing font family, changing color, and applying stroke), change background color, rotate objects, and align elements. In addition, the video presents the CRAP principles that the participants are asked to apply when creating the infographic. More specifically, the video presents a definition of each visual design principle followed by two examples that illustrate how to apply the principle. At the end of the video, participants are informed that they can raise questions at any moment during the design task.

**Design Tool**

The researcher provides a PowerPoint file with the same interface as jMap (Jeong, 2020b) used in the pilot study (Figure 4). Replicating the jMap interface into PowerPoint allows participants to work with familiar software and improves usability features limited in jMap (e.g., selecting multiple textboxes simultaneously). Also, providing the same design tool helps control for individual differences in familiarity and previous experience utilizing other existing tools (i.e., controlling the digital design dimension in the IDM). Participants receive the file containing the text, icons, and information about the CRAP principles and work on their own devices, following Nuhoğlu Kibar and Akkoyunlu’s (2018) study that requested participants to use the same tool and allowed them to work on their own instruments for more comfort and easiness.

**Adapted Version of the Infographic Design Rubric**

Two additional graphic design experts are recruited to score the participants’ infographics using an adapted version of the Infographic Design Rubric (Nuhoğlu Kibar & Akkoyunlu, 2017). The adapted rubric includes 17 4-point scale criteria ranging from “unacceptable” to “exemplary” and excluded rubric items that did not apply to the design task (e.g., items related to image selection). Seven of these criteria measure visual design qualities in the big picture sub-dimension (e.g., alignment and contrast) and 10 items measure the design component sub-dimension (e.g., fonts and colors). See Appendix D for the complete rubric. The adapted version
excluded rubric items that were not relevant to the application of the CRAP principles (Williams, 2008) evaluated in this study.

Following the procedures developed and tested in the pilot study, two graphic design experts and the researcher used the adapted rubric to score the infographics of ten participants. The raters watch a video explaining each rubric item and demonstrating how to rate an infographic. Next, the raters separately score one infographic, compare their scores, and resolve disagreements with the aim of achieving a high level of inter-rater reliability. Both raters and the researcher then independently score the infographics. In the pilot study, the scores between the raters and researcher were high in reliability, with an average measure ICC of .88 ($F(9,18)= 8.46, p < .001$) and 95% CI (.65 to .97).

Figures 5, 6, and 7 shows examples of a high-, average-, and low-rated infographic with the mean scores for each rubric item, respectively. These examples are presented to the two recruited scorers in the process of training them on the scoring process.

Figure 5. High-rated infographic and scores (Kuba & Jeong, 2023)
Figure 6. Average-rated infographic and scores (Kuba & Jeong, 2023)

Figure 7. Low-rated infographic and scores (Kuba & Jeong, 2023)
Procedures

All ten cases are conducted separately following the same procedures, as suggested by Creswell and Poth (2018) to use the logic of replication in a collective case study. The network connections between the researcher and design experts are used to identify and invite possible graphic design experts to participate in the study. Once selected, the participants are informed of the study’s purpose (i.e., explore how people use design principles when creating a visual composition), eligibility, duration (i.e., approximately 70 minutes), format (i.e., online via Zoom), and compensation (i.e., $15 gift card). The college-student participants are recruited by asking colleagues across different departments (e.g., computer sciences and psychology) to forward an email invitation to potential participants. The email invitation presents the study’s purpose, criteria for eligibility, duration, format, and compensation.

Once a participant is identified as eligible and willing to participate, each participant is contacted to schedule a time and day to perform the design tasks via a virtual meeting. At the beginning of the session, participants review and sign a consent form. The researcher reads the pre-made script discussed earlier that includes the assurance to the participant that they can withdraw from the study at any point in time and are informed that they will receive a gift card when and only when they complete the entire session. Next, participants study the slide presentation and respond to the assessment. Then, participants watch the 5-minute introductory video explaining the design task. The researcher then asks permission to start recording the video and audio of the session, asks the participants to respond to the demographic questions, informs the participants that the task can take roughly 40-50 minutes but are able to take as much time as needed, informs them that they will be asked to talk aloud to share their thoughts as they are performing the task and that they will may be reminded by the researcher to talk aloud after any extended periods of silence, and answers any questions from the participant prior to starting the design task. This introductory portion of the meeting lasts approximately 25 minutes in duration.

After the introduction, the participant is presented with the design tool on the computer screen. During the design task, the researcher asks prompt questions when the participant is not thinking out loud. At no time does the researcher provide any guidance of any kind on how the participant are to design the infographic other than providing assistance with the use of the infographic tool. When participant finishes the infographic, the participants is asked to share any questions and the researcher responds to the participant’s questions. To ensure data on the design
processes is thorough, the research prompts the participants to reflect and describe how they used the design principles. Each participant completing the entire session from start to end receive a gift card via email.

**Data Sources**

In a collective case study, the researcher strives to acquire an in-depth understanding of the cases by collecting multiple forms of data, such as images, videos, and observation notes (Creswell, 2018). This study will employ the following data sources.

**Assessment Scores**

Prior knowledge of the content can moderate how well a participant performs a task, such as designing infographics (Weinberger et al., 2007). Thus, the researcher provides multimedia learning material explaining the content to ensure all participants comprehend the content and gather data on participants’ understanding through assessment. Participants’ scores in the assessment are then used to measure prior-knowledge equivalence (i.e., learners having similar individual knowledge) regarding the content used to design the infographics.

**Demographic Data**

Researchers collect demographic to obtain background information on the participants to better analyze congregated data of the study (Creswell, 2018). In this study, the demographic data serves four purposes: (1) to confirm the participant’s eligibility for the study, (2) to gain insights into the participant’s prior experience, (3) to promote transferability by generating a detailed description of the participants, and (4) to expand on the findings of the pilot study that studied the processes used by experts and instructional designers with prior knowledge and coursework on visual design. Transferability is one of the quality criteria in qualitative research concerning “the degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents (Korstjens & Moser, 2018, p. 121)”.

38
Design Task with Think-Aloud Protocols

As the participants perform the design task, they are prompted using a think-aloud protocol to share their thoughts and thinking processes as they design the infographic. The design task will generate two types of data:

1. **Video screen recordings.** The screen is recorded using the Zoom™ video conferencing system that captures both the events performed on the screen and the participants’ camera.

2. **Audio transcripts.** The audio of participants’ thinking-aloud are also recorded using the Zoom™ video conferencing system that is saved in a separate audio file of the session. Each audio file from each session are then transcribed for analysis.

Infographics Quality Scores

Each participant’s infographic receives a total score obtained from the sum of the big-picture and design component sub-dimension criteria and two separate scores for each of the sub-dimension. The infographic quality score will be used to classify participants into high and low performers, discussed next.

Data Analysis

Coefficient of Variation

Researchers can compute measures of dispersion to analyze differences in prior knowledge in small group sizes (Weinberger et al., 2007). In this study, prior-knowledge equivalence is measured using the *coefficient of variation* to indicate the extent to which students diverge, being dissimilar from the group mean, as recommended by Weinberger et al. (2007). The coefficient of variation is the standard deviation of a group divided by the group mean, with lower values indicating more equivalence in prior knowledge. It is expected that students have similar understanding of the content after reading the multimedia learning material; thus, a low coefficient of variation (e.g., < 0.1) is aimed.

Analysis of Themes

As reported by Creswell and Poth (2018), the analysis of themes represents the heart of qualitative inquiries. It is an iterative process that consists of creating and applying codes,
developing themes, and providing an interpretation based on their views or views in the literature. The study will use Boris (Behavioral Observation Research Interactive Software, 2021) to code the design actions (e.g., increase font size) performed and/or verbalized by each participant. The coding process begins with a small list of design actions previously identified in the pilot study (Table 4), following Creswell and Poth’s (2018) recommendation to start with lean coding (i.e., start coding with a short list and only expand the list as necessary). Each video recording undergoes several rounds of analyses during the coding process to identify the design actions and classify them into themes. Themes represent the general function of each design action (e.g., a participant increases the font size of the title to create a visual hierarchy). When a new design action is observed that does not fall into the current list of themes, a new theme is created and added to the list.

<table>
<thead>
<tr>
<th>Design action</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change font family</td>
<td>Change font from Arial to Calibri</td>
</tr>
<tr>
<td>Increase or decrease font sizes</td>
<td>Change font size from 12 points to 14 points</td>
</tr>
<tr>
<td>Change font styles</td>
<td>Applying bold to a word or sentence</td>
</tr>
<tr>
<td>Change colors</td>
<td>Applying color to a text or shape</td>
</tr>
<tr>
<td>Place and arrange elements on the canvas</td>
<td>Dragging elements to an area in the canvas</td>
</tr>
<tr>
<td>Create shapes</td>
<td>Combine a rectangle and a triangle to form a new shape</td>
</tr>
</tbody>
</table>

**Triangulation of Multiple Data Sources**

Data triangulation is used to help further identify and refine observed themes and develop interpretations (i.e., make sense of the data). Triangulation is the process of using multiple sources, methods, or researchers to provide supporting evidence for shedding light on a theme and validating the accuracy of a study (Creswell & Poth, 2018). This study employs methodological triangulation, which refers to interpreting data gathered from different data collection methods (Korstjens & Moser, 2018). More specifically, this study triangulates the data from the transcribed think-aloud during the design task with content analysis from video recordings, and from participants’ post-task reflections and descriptions of the design principles.
applied in the infographic. For example, the researcher codes a design action observed in the video recording (e.g., the participant changed the title’s font size) and analyzes the verbal explanation from audio file containing the think-aloud protocol (e.g., the participant verbally expresses the desire and decision to make the title bigger than the subtitle) to identify a theme (e.g., establish visual hierarchy).

Descriptive Statistics of Infographic Scores

The study will compute each participant's infographic score to classify them into high and low performers. The infographic scores are standardized by subtracting the sample mean from the observed score and dividing the result by the standard deviation of the sample. In this study, participants with scores above the mean will be classified as high performers and those with score below the mean as low performers. Lastly, descriptive statistics such as mean infographic score, mean weighted scores, and respective standard deviations for each group (i.e., low- and high-performers) are computed and reported in the results.

Temporal Event and State Sequences

Temporal event sequences are a type of data visualization technique that presents long sequences of data visually, such as a single stream of actions, showing readers a visual story (Dunn, 2022). In a plot of temporal event sequences, the x-axis often presents the graduation in time at a given scale (e.g., seconds and minutes) while the y-axis presents numeric values. In this study, we will compute the sequence of all themes performed by each participant using second as the time incremental. The plot of temporal event sequences will be generated using Plot Events™ feature in BORIS (Friard & Gamba, 2016), see example in Figure 8. The x-axis displays the graduation in time and the y-axis displays the participants ordered according to their overall weighted score. Thus, the plot will show a single stream of theme sequences that each participant devoted to designing an infographic.

Also, the plot identifies the state sequences that participants engaged in each theme. State sequences refer to the duration of particular behavioral states or events, informing the proportion of the observation time devoted to a specific event (Bakeman & Gottman, 1997). For example, in the pilot study, high-performers spent 29% of the time setting a structure and 21% replicating design decisions and low performers spent 14% setting a structure and 6% replicating design
decisions. Lastly, a Chi-square test will be conducted to determine any statistical difference in time percentage spent on each theme between groups.

Figure 8. Plot of temporal event sequences (Kuba & Jeong, 2023)

Sequential Analysis

Once the video and audio recordings are coded to identify the actions (identify by theme) that are performed by each participant (and chronologically logged) in the course of designing the infographics, the actions are sequentially analyzed using DAT software (Jeong, 2018) to identify patterns in action sequences following three measures suggested by Jeong (2019): (1) analyze the coded design actions to count the number of times each theme was followed by another given theme, (2) calculate the transitional probabilities between any two given actions (i.e., the likelihood that theme A is followed by theme B relative to all other possible themes A through Z), and (3) identify sequential patterns by detecting transitional probabilities significantly higher and lower than the expected probability based on the $z$-scores at $p < .05$.

In DAT software, the actions sequences across each group of participants are sequentially analyzed to generate transitional frequency, transitional probability, and $z$-scores matrices. Figure 9 shows the three matrices for high-performers in Kuba and Jeong (2023). The transitional frequency matrix is a simple table in which each cell indicates the number of times a specific transition occurred (e.g., theme A was followed by theme C nine times). The transitional
Probabilities are calculated by dividing a particular cell by the total frequency of the row (Bakeman & Gottman, 1997). For instance, in Figure 9, the transitional probability between themes A and C is .28, which is equal to 9 (number of times A was followed by C) divided by 32 (the total number of times theme A was followed by another theme). In other words, the probability of theme C occurring, given that theme A just occurred, is 28%.

Finally, the z-scores matrix identifies the transitional probabilities that deviate significantly from the expected values. A z-score compares observed to expected values, which the latter is computed assuming independence, that is, no association between the cells of the matrix (Bakeman & Gottman, 1997). The formula for calculating the expected value and z-scores for sequential analysis (Bakeman & Gottman, 1997, p. 108-109; Jeong, 2018) are as follows:

\[
\text{Expected value} = Y = \frac{R + C}{T}
\]

\[
\text{z-score} = \frac{X - Y}{\sqrt{Y \left(1 - \frac{R}{T}\right) \left(1 - \frac{C}{T}\right)}}
\]

In the formulas, \(Y\) is the expected value, \(X\) is the observed value, \(R\) is the sum of the observed frequencies in a specific row, \(C\) is the sum of the observed frequencies in a particular column, and \(T\) is the total number of two-theme chains tallied (Bakeman & Gottman, 1997). For example, in Figure 9, the z-scores highlighted in green and red represent the transitional probabilities that were statistically significantly higher or lower than the expected value with \(p < .05\), respectively. The transitional probabilities highlighted in green and red denote what “patterns” are revealed in the action sequences exhibited by each group. The values from the transitional probability and z-scores are then represented via transitional state diagrams generated in DAT software to visually/graphically convey observed sequential patterns performed within each group in higher-than-expected frequencies (Figure 10). In the transitional state diagrams, black arrows identify probabilities significantly higher than the expected probability by chance alone based on z-score tests (\(p < .05\)), determining action sequences that form a sequential pattern. The gray arrows identify probabilities not significantly higher than expected, identifying action sequences that are not deemed to be a pattern. The thickness of each arrow conveys the relative size of the observed probability, with thicker arrows indicating higher probabilities.
Ultimately, the results of the data analysis, particularly the significant sequential patterns, are summarized and encapsulated in a visual process model that lay out the key steps in the process of designing infographics, specifically in the visual design dimension.

Figure 9. Transitional frequency, transitional probability, and z-scores matrices of six themes generated in DAT software (Kuba & Jeong, 2023)

Note. Black and gray arrows denote transitional probabilities that are and are not significantly higher than expected, respectively, based on z-scores at $p < .05$. The thickness of each arrow conveys the relative size of the observed probability, with thicker arrows indicating higher probabilities.

Figure 10. Transitional state diagrams (Kuba & Jeong, 2023)
Trustworthiness

Below is the description of how this study account for the following quality criteria defined by Guba (1981) to establish trustworthiness in qualitative research: **credibility**, **transferability**, **dependability**, and **confirmability**.

Credibility

According to Guba (1981), credibility is equal to internal validity in quantitative research, concerning the confidence that can be placed in the accuracy of the research findings. This study will employ four strategies to ensure credibility: (1) triangulation of data sources, (2) persistent observation, (3) use of validated rubrics, and (4) report of participants’ direct quotes. Qualitative researchers can triangulate information to provide validity for research findings by corroborating evidence to register a code or theme in multiple data sources (Creswell & Poth, 2018). As discussed earlier, this study uses methodological triangulation by collecting data using different methods (e.g., video screen recordings and transcribed think-aloud). Persistent observation refers to iteratively reading, rereading, and analyzing the data until all themes are documented and explored in-depth (Korstjens & Moser, 2018). In this study, all videos will go through numerous rounds of analyses to identify the design actions and classify them into themes. If a video provides further insights into the coding process or presents a new design action or theme, the researcher will revise all previous videos accordingly.

Moreover, this study uses a validated rubric to score the infographics with an intraclass correlation (ICC) of .88 ($F(9,18)= 8.46, p < .001$) and 95% CI (.65 to .97). The rubric was adapted from the Infographic Design Rubric (Nuhoğlu Kibar & Akkoyunlu, 2017) that also presented high reliability in previous testing (i.e., ICC values ranging from 0.77 to .97, with 95% CI). Lastly, as suggested by Korstjens and Moser (2018), this study will report direct quotes from participants’ original data to support research findings and interpretations.

Transferability

Transferability refers to applicability (Guba, 1981). A qualitative researcher can promote transferability through thick descriptions, permitting readers to evaluate if the findings are transferable to their setting (Korstjens & Moser, 2018). This study will report detailed descriptions of the research methods, such as purposeful sampling, data sources, instruments,
inclusion and exclusion criteria, and demographic data, such as participants' characteristics and the context in which the research was carried out to foster transferability.

**Dependability and Confirmability**

Dependability refers to the consistency or stability of data. To ensure dependability, researchers check whether the analysis procedure adheres to the accepted standards for a specific research design (Guba, 1981; Korstjens & Moser, 2018). Confirmability concerns the idea of impartiality and the degree to which the findings could be confirmed by other researchers (Korstjens & Moser, 2018). The interpretations must be grounded in the data rather than the researcher's personal preferences and viewpoints, meaning that the inter-subjectivity of the data must be protected (Guba, 1981). Researchers (e.g., Creswell & Poth, 2018; Korstjens & Moser, 2018) recommend using audit trail or peer review debriefing to foster dependability and confirmability. This study employs the latter by providing descriptions of decisions made during the research process, sampling, research materials adopted, and information about the data management to peer debriefers (i.e., dissertation committee). According to Creswell and Poth (2018), a peer debriefer is a person, often colleagues or professors in the case of students, who holds the researcher accountable, and challenges techniques, interpretations, and meanings. Lastly, another strategy suggested by Guba (1981) to ensure dependability is using overlapping methods to triangulate data, discussed earlier.
CHAPTER 4
RESULTS

Pre-Knowledge Equivalence

Among all participants, the average score in the 12 multiple-choice assessment was 10.8 (min = 10, max = 12, SD = 0.75). The coefficient of variation was 0.07, meaning that after reading the multimedia material, all participants had similar understanding about the content used to compose the infographics (i.e., CRAP principles), with a dispersion of 7%. Furthermore, for the design experts, the average score was 11 (min = 10, max = 12, SD = 1.00) and for the non-design college students was 10.6 (min = 10, max = 11, SD = 0.42).

Infographics Ratings

Reliability Analysis

The intraclass correlation is computed using absolute agreement in a two-way mixed effects model where individual effects are random and measures effects are fixed. The scores between the two raters and researcher were high in reliability, with an average measure ICC of .967 (F(9,18)= 42.89, p <.001). Particularly for the big-picture dimensions, the average measure ICC was .964 (F(9,18)= 29.84, p <.001). For the design component sub-dimensions was average measure ICC of .961 (F(9,18)= 38.99, p <.001).

Standardized Scores Used to Separate High vs Low Performers

Among the ten designers participating in this study, 6 were classified as high performers with standardized scores above the mean and 4 were identified as low performers with standardized scores below the mean. Also, the lowest standardized score for the high performers (i.e., 155.85) was greater than one standard deviation (i.e., 39) in comparison to the highest standardized score for the low performers (i.e., 116.85). The 6 high performers included 5 graphic designers and 1 college students from electrical engineering. The low performers included 4 non-design college students. Table 5 shows the descriptive statistics of infographic overall scores and Figure 11 displays the scatterplot and whisker plot for all scores.

The average standardized score was 149.4 (SD = 36.03) and the highest possible score was 204. For the high performers, the standardized average score was 171.69 (min = 155.85, max = 185.85, SD = 11.53) and for the low performers, the standardized average score was
105.60 (min = 88.85, max = 116.85, SD = 13.35). The average score for the big picture sub-dimension, which included 7 rubric items (i.e., the highest possible score was 84), was 61.30 (SD = 14.31), and 71.17 (SD = 6.52) for the high performers and 46.50 (SD = 7.55) for the low performers. Regarding the design component sub-dimension, which included 10 rubric items (i.e., the highest possible score was 120), the average score was 88.10 (SD = 22.70), and 104.67 (SD = 5.32) for the high performers and 63.25 (SD = 11.24) for the low performers. Examples of high and low-rated infographics are presented in Figures 12, 13, 14, and 15.

Table 5. Descriptive statistics of infographic overall standardized scores

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Total scores</th>
<th></th>
<th>Big picture</th>
<th></th>
<th>Design component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean  SD  Min  Max</td>
<td>Mean  SD</td>
<td>Mean  SD</td>
<td>Mean  SD</td>
<td></td>
</tr>
<tr>
<td>High performers</td>
<td>6</td>
<td>171.69  11.53  155.85  185.85</td>
<td>71.17  6.52</td>
<td>104.67  5.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low performers</td>
<td>4</td>
<td>105.60  13.35  88.85  116.85</td>
<td>46.50  7.55</td>
<td>63.25  11.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>149.40  36.03  88.85  185.85</td>
<td>61.30  14.31</td>
<td>88.10  22.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. The green dots represent the high-rated infographics, and the blue dots the low-rated infographics.

Figure 11. Whisker plot and scatterplot for the standardized total scores
Four design principles for visual composition

**Contrast**
Creates focal points by arranging opposite elements in a composition
- Use different sizes for different purposes
- Use bold type to create contrast

**Repetition**
Ties elements together and creates a sense of unity and cohesiveness
- Use colors to form a pattern
- Use same styles to group elements

**Alignment**
Indicates organization and improves the readability of your design
- Line up elements to the grid
- Use text justifications

**Proximity**
Creates relationships within elements in a composition
- Place related elements together
- Place unrelated elements spaced apart

Figure 12. High-rated infographic (score = 181.85)

Figure 13. High-rated infographic (score = 169.85)
Figure 14. Low-rated infographic (score = 116.85)

Figure 15. Low-rated infographic (score = 88.85)
Infographic Rubric Items

The rubric also identifies specific areas in which participants excelled and needed work. The highest and lowest-ranked items differed between high and low-performers (Table 6). Also, high-performers ranked competent or exemplary (i.e., a score of 3 or 4) in most items, and low-performers mostly unacceptable or needing work (i.e., a score of 1 or 2).

Table 6. Average score and standard deviation per rubric item

<table>
<thead>
<tr>
<th>Rubric item</th>
<th>Example</th>
<th>High performers</th>
<th>Low performers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Big-picture sub-dimension</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>Repetitions create unity and consistency</td>
<td>4.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Proximity</td>
<td>Proximity is based on the message</td>
<td>3.89</td>
<td>0.32</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Visual hierarchy is consistent with the significance of the information</td>
<td>3.44</td>
<td>0.70</td>
</tr>
<tr>
<td>Contrast</td>
<td>Distinct components stand out</td>
<td>3.39</td>
<td>0.78</td>
</tr>
<tr>
<td>Alignment</td>
<td>Components are aligned on the page</td>
<td>3.39</td>
<td>0.61</td>
</tr>
<tr>
<td>Balance</td>
<td>There is a balance between the text, visuals, and white space</td>
<td>2.94</td>
<td>0.94</td>
</tr>
<tr>
<td>Emphasis</td>
<td>Fundamental information is highlighted</td>
<td>2.67</td>
<td>1.03</td>
</tr>
<tr>
<td><strong>Design component sub-dimension</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Font type</td>
<td>Fonts are legible and distinct</td>
<td>3.83</td>
<td>0.38</td>
</tr>
<tr>
<td>Font color</td>
<td>Font color increase readability</td>
<td>3.72</td>
<td>0.46</td>
</tr>
<tr>
<td>Font size</td>
<td>Different font sizes improve readability</td>
<td>3.56</td>
<td>0.51</td>
</tr>
<tr>
<td>Font case</td>
<td>Use of upper-lower case creates dynamism</td>
<td>2.39</td>
<td>0.78</td>
</tr>
<tr>
<td>Line length</td>
<td>Line lengths allow for smooth reading fluency</td>
<td>3.72</td>
<td>0.46</td>
</tr>
<tr>
<td>Line spacing</td>
<td>Line spacing allows for easy reading</td>
<td>3.61</td>
<td>0.61</td>
</tr>
<tr>
<td>Justification</td>
<td>Justifications supports readability</td>
<td>3.72</td>
<td>0.67</td>
</tr>
<tr>
<td>Color effect on visibility</td>
<td>Colors promote legibility and readability</td>
<td>3.50</td>
<td>0.71</td>
</tr>
<tr>
<td>Color harmony</td>
<td>Color palette is harmonious and obtained through selection of different tones</td>
<td>3.67</td>
<td>0.49</td>
</tr>
<tr>
<td>Background color</td>
<td>Background color draws the attention to the text and visual components</td>
<td>3.17</td>
<td>0.38</td>
</tr>
</tbody>
</table>
The three highest-ranked items in the high-performers group were Repetition (Mean = 4.0, SD = 0), Proximity (Mean = 3.89, SD = 0.32), and Font Type (Mean = 3.83, SD = 0.38), and the three lowest-ranked items were Emphasis (Mean = 2.67, SD = 1.03), Balance (Mean = 2.94, SD = 0.94), and Font Case (Mean = 2.39, SD = 0.78). Except for the three lowest-ranked items mentioned before, 14 out of 17 items were competent or exemplary (i.e., score > 3).

For the low-performers group, the three highest-ranked were Repetition (Mean = 3.25, SD = 0.87), Line Length (Mean = 2.92, SD = 0.67), and Line Spacing (Mean = 2.83, SD = 0.39). The three lowest-ranked items were Balance (Mean = 1.75, SD = 0.75), Background Color (Mean = 1.58, SD = 0.90), and Color Effect on Visibility (Mean = 1.17, SD = 0.39). Additionally, 16 items had means scored as either unacceptable or needing work (i.e., score < 3).

Visual Design Processes

RQ1: What visual design processes are used by graphic design experts and non-design college students to generate higher and lower quality infographics?

This section presents the six visual design processes identified in the triangulation of data sources (think-aloud, video content analysis, and short interviews), the temporal event sequences depicting the aggregated visual design process sequences of the participants by groups in chronological order, the transitional probabilities between the six design processes, and the sequential patterns in the design processes based on the results of the transitional probabilities and event sequences.

In this study, themes denote the overall function of a design action (e.g., a participant arranged the canvas into four columns to create a structure). Results revealed six themes, referred to as visual design processes, observed in the production of the high- and low-rated infographics, and a total of 19 design actions were identified and categorized into one of the following six design processes:

1. Create structure and grid: create a layout or grid and determine the spatial zone for an element.
2. Establish visual hierarchy: make elements stand out based on the significance of the information.
3. Define visual rules: select fonts, colors, and graphic elements to specific elements.
(4) *Replicate visual rules*: repeat the defined visual rules to congruent information (e.g., all subtitles have the same color and formatting).

(5) *Test and adjust*: duplicate a slide to test different colors and graphics while maintaining the overall structure and adjusting alignments.

(6) *Validate and revise*: look at and evaluate the overall design, compare the before and after design decisions, and make minor corrections.

Table 7 lists the six visual design processes, their respective design actions, and the percentage of time spent in each design process by low and high performers. A Chi-square test revealed the percentage of time for each design process statistically differed among high and low performers $\chi^2 (5, n = 200) = 13.12$, $p = .02$. Also, the percentage of time for high-performers in this study was *not* statistically different from the high-performers in the pilot study ($\chi^2 (5, n = 200) = 9.87$, $p = .08$), showing the time distribution between design processes were somewhat comparable among high-performers in both studies. In general, high performers spent triple the time replicating visual rules (21%) compared to low performers (7%) and more time testing and adjusting (16%) compared to low performers (10%). High performers may have spent more time testing and adjusting since half tended to duplicate their slides to try new options regarding colors and graphics and almost all tended to fixate over precise alignments. Low performers spent more time setting a structure (28%) and working on fonts, colors, and graphic elements (35%) than high performers (21% and 23%, respectively). Lastly, the percentage of time spent establishing a visual hierarchy and validating the design was more similar between the groups.

The average time completion for high performers was 46 minutes (min = 13, max = 70, $SD = 20$) and 32 minutes (min = 21, max = 43, $SD = 11$) for low performers. High performers, especially graphic designers, tended to obsess over alignment and spent around 20 minutes testing and adjusting compared to non-designers, who spent roughly 7 minutes. Part of the time was due to software limitations. One graphic designer mentioned: “*It is not easy to make perfect alignment and proportions here. The alignment bothers me a little, but it is okay.*” However, despite the limitations, all graphic designers tried to align elements precisely. One mentioned that the fixation over alignment is compulsive, and another noted that “*I am now aligning by eyeballing; otherwise, we are staying here till tomorrow.*” Specific strategies regarding alignment are discussed later.
Non-design students, on the other hand, did not know the design possibilities. They would finish placing elements on the canvas and verbalize not knowing what to do next. One computer science student said: “Basically, my design is done. I don’t know what to do. I have to make it appealing, right? I think maybe adding boxes?”. Additionally, two students asked what they could do. The researcher listed a few possibilities, such as changing the background color, adding shapes, and playing with fonts and colors, and emphasized that engaging in any of these options was their choice. In one case, the researcher noted that the student was staring at the canvas, not knowing what to do next, and stated: “If you feel like you are finished, that's fine”, to which the student promptly replied: “Yeah. Okay. I think I am finished.”

Table 7. Visual design processes, design actions, and percentage of time spent in each process

<table>
<thead>
<tr>
<th>Visual design process</th>
<th>Design actions</th>
<th>Time distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low-rated</td>
</tr>
<tr>
<td>Create structure and grid</td>
<td>Place and arrange elements on the canvas; determine the spatial zone for an element; count the number of informational units (i.e., sub-topics); create grid (margins, columns, rows, and gutters); and align elements to the grid</td>
<td>28%</td>
</tr>
<tr>
<td>Establish visual hierarchy</td>
<td>Count the number of heading/text levels; change font sizes and styles based on the significance of the information; and format the main title to make it stand out</td>
<td>7%</td>
</tr>
<tr>
<td>Define visual rules</td>
<td>Select font family; choose colors; create shapes; and add background color</td>
<td>35%</td>
</tr>
<tr>
<td>Replicate visual rules</td>
<td>Repeat styles to congruent information</td>
<td>10%</td>
</tr>
<tr>
<td>Test and adjust</td>
<td>Duplicate slide to test new colors or graphic elements without changing the structure and checking alignment between elements</td>
<td>7%</td>
</tr>
<tr>
<td>Validate and revise</td>
<td>Look at and evaluate the overall design, making minor corrections, and compare before and after design decisions</td>
<td>13%</td>
</tr>
<tr>
<td><strong>Total time:</strong></td>
<td></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Moreover, all non-design students mentioned using built-in themes in the software and just changing the text. Lastly, three non-design students affirmed enjoying the new experience of creating their own design. One student mentioned: “I enjoyed creating an infographic. I didn’t know what I was doing because I usually stick with a theme and just change the text. This time I
was thinking about things to be improved, such as colors and fonts. I pushed myself to do something pretty”.

Temporal Event Sequences

Figure 16 shows the aggregated visual design process sequences of the participants by groups to reveal differences between low and high performers. In general, the visual design processes used to produce the high-rated infographics were more structured. The process began with work on the structure and visual hierarchy, followed by defining and replicating visual rules, and finally followed by testing and adjustments, and validation. Further, high performers started planning the structure based on the content. For instance, since the content included four subtopics, they considered a layout of four columns or two columns by two rows. Then, high performers engaged in an iterative process between working on the structure and establishing a visual hierarchy as they would determine font sizes based on the significance of the information and define spatial zones for each informational unit (e.g., one column per subtopic and one-third of the horizontal space for the main title). Also, establishing a visual hierarchy started at the beginning of the design process and was completed within the first one-fifth of the time.

Next, they tended to create visual rules by defining a font family, styles (e.g., bold and bullet points), alignment, and colors for one informational unit -- represented by the small purple chunks at the beginning of the plot in Figure 16. After defining visual rules, high performers applied the rules for the remaining units, which took place from 20% to 60% point of time. Moreover, after completing the structure, which continued to and was concluded at or near the halfway point in the design process, they spent time duplicating the design and testing different colors and graphics. For instance, they would select new colors and graphics and adjust the design to accommodate the testing, represented by the large purple chunks (i.e., creating visual rules) intercalated with the pink chunks (i.e., testing and adjusting). Lastly, validation was performed closer to the end of the design process, near the last one-fifth of the time, and appeared in an iterative process with adjustments.
In contrast, the processes used to create the low-rated infographics were less structured given that work on structure continued and was completed only nearly 70% point in the design process. Also, developing visual rules, especially selecting fonts, colors, and graphics, was widely scattered through the design process and validation was executed at more sporadic times rather than closer to the end of the design process. Similar to the high-rated infographics, establishing a visual hierarchy was performed at the beginning of the design process and completed by the 20% point. However, replicating visual rules was a design process scarce in the low-rated infographics plot and occurred at different stages among low performers. For instance, replication appeared in the first half of two participants’ plots and in the second half for the other two participants.

In general, low performers started the design by placing one element on the canvas, such as the main title, then increasing font size to establish a visual hierarchy, working on colors and details, and moving to place the next element. Contrary to high performers, low performers did not decide on a structure (e.g., a layout of 4 columns and 2 rows) before placing all elements, having to constantly re-structure the design to make room for the remaining elements –
represented by the scattered orange chunks throughout the design process. Thus, due to the continuous re-structuring, low performers spent more time on creating structure (28% of the time) compared to high performers (21%). Additionally, low performers worked on fonts, colors, and shapes with less intention of defining a visual rules. For instance, one participant decided to apply bold the word “bold” in the Contrast subtopic to illustrate the meaning of the word; but did not replicate this strategy to all subtopics.

Lastly, when replicating design decisions, low performers repeated formatting options such as font family, font size, colors, and arrangements but not details such as alignment and distances. High performers were much more strict with the replication actions. They replicated attributes, such as distances between each subtitle to the text description, padding between the paragraph and the textbox, and the number of lines of each text description. For instance, high performers would change the textbox width to ensure all text descriptions across the four subtopics occupy three lines. Specific strategies regarding defining and replicating visual rules are discussed later.

**Transitional Probabilities between Design Processes**

The transitional probabilities between the six design processes were computed to produce a transitional state diagram for each group to compare and identify differences in the processes used by the low- and high-performers (Figure 17). It is possible to identify some unique patterns in the visual design processes used by each group (i.e., low and high performers) by comparing the state diagrams. The value shown within each node informs the percentage of time spent performing the particular action. The arrows indicate which action(s) were most likely to follow any given action. For instance, the black horizontal arrow pointing from ‘Set structure’ to ‘Establish visual hierarchy’ in the high-rated infographics diagram indicated that 49% of all events following ‘Set structure’ was ‘Establish visual hierarchy’. Black arrows denote probabilities significantly higher than the expected probability by chance alone based on z-score tests \( p < .05 \), defining action sequences that form a sequential pattern. The gray arrows denote probabilities not significantly higher than expected, determining action sequences that are not considered to be a pattern. The thickness of each arrow suggests the relative size of the observed probability, with thicker arrows representing higher probabilities.
The side-by-side comparison of the two diagrams in Figure 17 reveals that the design processes used to create high-rated infographics were more linear and iterative in process. The most noticeable differences between the groups were:

- In the high-rated group, the second design process most followed by Visual Hierarchy was Defining Visual Rules (although not significant), suggesting a linear process starting from Set Structure → Establish Visual Hierarchy → Define Visual Rules → Replicate Visual Rules → Test and Adjust → Validate.
- In addition to the linearity, the state diagrams revealed that the high-rated exhibited a total of three iterative processes (Structure ↔ Visual Hierarchy, Define Visual Rules ↔ Validation, and Test and Adjust ↔ Validate).
- The low-rated group exhibited only one iterative process (Define Visual Rules ↔ Validation).
- The average number of transitions for the high performers was 48 (min = 33, max = 64, $SD = 11$) and 69 (min = 70, max = 100, $SD = 26$) for the low performers. Despite executing more design process transitions, low performers presented 5 significant transitions with one iterative process, while the high-rated group displayed 9, including 3 iterative processes.
Sequential Patterns in the Design Process

The state diagrams and temporal event sequence plots (Figure 16) show that high performers engaged in a more linear process compared to low performers. The state diagram for the high-rated group (Figure 17) confirms the iterative process between working on the structure and establishing a visual hierarchy discussed earlier (e.g., deciding font sizes for visual hierarchy influences the definition of spatial zones for setting a structure). The diagram also corroborates that high performers would first define visual rules and then apply them to the overall design (Define Visual Rules → Replicate Visual Rules). Moreover, after attaining one satisfactory design (i.e., a design with built structure and visual hierarchy and consistent application of visual rules), high performers would duplicate the design and test different colors and graphics (Test and Adjust → Define Visual Rules) while validating the new decisions and comparing the produced designs (Define Visual Rules ↔ Validation ↔ Test and Adjust).

Moreover, for low performers, the state diagram displays a significantly higher probability than the expected ($p < .05$) in the sequence Define Visual Rules → Structure that is presented as low probable in the high-rated group. This transition along with the results from the triangulated data suggest that low performers did not place and organize all elements before defining visual rules and tended to work on fonts, colors, and graphics as they positioned a new element on the canvas (Define Visual Rules → Structure). Also, low performers exhibited a transition between Structure → Establish Visual Hierarchy that was not iterative as it was for high performers. Further, since the low-rated group did not tend to duplicate the slide and test new designs, they did not exhibit the iterative process between Test and Adjust and Validation, as the high-rated group did.

Visual Design Strategies

RQ2-3: What unique visual design strategies are used in higher-quality and lower-quality infographics?

This section presents six categories of visual design strategies identified in the triangulation of data sources, primarily from the transcribed think-aloud and video content analysis. Each category includes specific techniques and examples.
1. Defining image dimensions based on publication media

Although designers could not change the canvas dimension (i.e., width and height), high performers mentioned that they decide the format based on where the medium will be published. For example, a high performer stated choosing wide layouts with a 12-column grid for websites and square sizes for social media. Another design expert noted that understanding where the medium will be displayed influences certain design decisions, such as margins, font size, and colors. For instance, three high performers mentioned adding larger margins for printed than digital materials to ensure important information will not be cropped out and selecting bigger font sizes for digital than printed materials. In terms of colors, one high performer mentioned that: “I make decisions on colors depending on where the image will be exhibited. I think whether I add a background color based on the elements around the infographic. For instance, I examine the visual communication of a magazine page where the infographic will be placed to select colors and graphic elements”. Low performers, on the other hand, did not question or verbalized strategies for choosing different formats.

2. Breadth-first over depth-first approach

The verbal protocol analysis revealed that the high performers used more of a breadth-first approach by focusing on structure (spatially organizing some or all of the informational units) before working on the details of selecting font formatting, colors, and graphics for each unit of information. “Now I have the ‘backbone’ of the infographic, and the four groups are defined with good space between them. The structure is ready. What I would do now is refine. Maybe adding shapes in the background or some graphic elements like creating boxes for each group.”. High performers would also define font sizes to support the Visual Hierarchy and better spatially organize the elements, as one stated: “Let me change the font size, so I can feel the space and get a sense of hierarchy”. The breadth-first process appears in the high performers’ diagram as a iterative process between Structure ↔ Visual Hierarchy (Figure 17). Low performers, on the other hand, tended to place and format one element at a time (e.g., one subtitle), utilizing a more depth-first approach. The video analysis showed instances where low performers would place a subtitle on the canvas and add details about fonts, colors, and graphics to it right away before placing and arranging another element. This process would occasionally left the low performers with insufficient space on the canvas to place the remaining elements.
3. Building a grid to structure a layout

High performers created a grid (i.e., a set of intersecting vertical and horizontal lines that structures a layout; Timothy, 2017) to set the structure and using the grid for aligning elements, as one designer noted: “First thing I would do is dragging guidelines to separate the four topics. I want to make the separations very distinct.” Also, high performers often considered layouts based on the structure of the content (e.g., building layout with four columns since the text included four topics). The primary components of their grid are (Figure 18):

- **Margins.** The area surrounding the content. High performers noted defining margins to know the space they have to work and secure a breathable space around the content. The high-rated infographics showed two approaches to set margins: equal margins for all sides of the design, centralizing the entire content in the canvas, and equal lateral margins and different equal upper and bottom margins.

- **Columns.** The vertical divisions inside the margins that organize and contain the content. The five highest-ranked high performers used columns to organize the space by dragging guidelines or creating shapes to define the columns (see Figure 19). One high performer mentioned creating a grid of 12 columns for more freedom, such as having sections occupying a different number of columns (e.g., three sections using 3, 6, and 3 columns, respectively).

- **Rows and Baselines.** The horizontal divisions and lines inside the margins that organize and align elements. Similar to creating columns, high performers would define rows by dragging guidelines. Baselines were lines added as they worked on the composition, for alignment purposes, such as aligning all subtitles to the bottom.

- **Gutters.** The space between columns. High performers applied gutters to support the proximity principle by ensuring the white space between groups made them look separate. For instance, one designer said: “I will decrease the width of the columns so I can increase the width of the gutters to separate more the subtopics”.

Figure 19 shows a grid built in the development of a high-rated infographic. The designer set identical margins to all four sides of the canvas displayed by the dotted lines. Next, she created a four-column structure using rectangles to help her place and align elements. Also, the designer equally distributed the rectangles inside the margins to have equivalent gutters between
them. She then used gridlines as baselines to align the subtitles across each column. Note that the shaded gray rectangles are not part of their design but structure segments to visualize the layout in support of the alignment and proximity principles. Although low performers created layouts using columns and rows, they did not create a grid beforehand. Also, gutters were verbalized and applied only by graphic designers who ensured all gutters between columns and rows had the exact measurement. Low performers did not consider gutters for supporting the proximity principle, making the subtopics not easily perceived as groups (see Figure 20).

Figure 18. Elements of a grid (Kuba, 2021)

Figure 19. Grid in a high-rated infographic
4. **Using spatial zones and typography to establish a visual hierarchy**

High performers tended to establish an early visual hierarchy by determining spatial zones (i.e., a section of a layout created for a particular purpose; Timothy, 2017) in the grid. For instance, in Figure 19, the designer assigned two-thirds of the grid for the body of text and icons and the upper one-third for the main title. Consequently, the main title was surrounded by a large white space, increasing the contrast between the title and the content and making the main title stand out. Further, high performers tended to position related information close to one another (e.g., subtopics separated by narrow gutters) and less related or content with different functions farther apart (e.g., distancing the subtitles from the text with white space) to support the proximity principle. Moreover, the analysis showed that all participants used font size and formatting to create a visual hierarchy. One strategy verbalized by a high performer was using an incremental of 8 points. For instance, he set the body of text to 16pt, the subtitles to 24pt, and the main title to 32pt: "I see that I have a description of the principle, the name of the principle, and the main title. So, I need three levels. I will start with 16 for the text and increase 8 points as the hierarchy goes up". The designer mentioned that for digital media, he uses font sizes with 16 to
18 points, but for printed materials, he usually selects a font size between 10 to 12. He explained that in digital materials, people tend to read from further away, and the designers often have to safe space in printed materials.

Additionally, high performers tended to test font sizes by increasing the size by around 4 points, while low performers tended to add one point at a time, taking more time to decide the font sizes. Apart from font sizes, participants used the following formatting to create a visual hierarchy: (1) using different weights, such as applying bold to subtitles and titles, (2) adding white space around the main title and subtitles, (3) adding color, and (4) adjusting the kerning (i.e., space between characters in a word) of the main title and subtitles. One high performer said: “The content is composed of a main title, subtitles, a description, and two examples. So, I will try to apply bold to the titles and bring other characteristics to make them different visually, even though they are part of the same topic.” That designer achieved her visual hierarchy by applying bold only to the title and subtitles, using bigger font size for the title and subtitles, adding white space around the main title, adding color just for the title and subtitles, and using bullet points to differentiate the two examples from the description (Figure 12).

5. Defining and replicating visual rules

A more top-down strategy was used by high performers to define visual rules (e.g., decisions on font, color, graphics, spacing) for a specific unit of information that visually distinguishes the informational unit from the other units (e.g., subtitles that all share equal font style and color in Figure 12), then replicating that scheme in the other units. For instance, in Figure 13, one high performer applied the light blue color to the box and all text associated with the Contrast principle and then repeated the same process using different colors with similar pastel tons for the remaining informational units. Further, all graphic design experts, classified as high performers, asked about a style guide or references when choosing fonts, colors, and shapes. Three mentioned they often do not spend much time selecting fonts and colors because they follow a brand style guide that includes specifications on these attributes.

Another noteworthy pattern was that high performers tended to keep the design simple. For example, they would choose no more than two font families and tended to select fonts they had familiarity as one designer expressed: “I selected Robot right away because it is a font I always use, and I know it is legible and clean.” When defining an overarching visual scheme,
such as selecting fonts, colors, alignments, and shapes to be used in the design, high performers tended to define and replicate more details than low performers. For example, all participants decided on fonts and colors, but only high performers determined and replicated details such as padding inside boxes and space between paragraphs. Below is a list of items when defining visual rules.

Items of a visual scheme worked by all participants:

- **Font family.** Most participants selected a different font family from the default in the software to compose the infographic and tended to use no more than two fonts. Two high performers mentioned using one sans serif font family since the purpose of the design is instructional: “*Since it is purely informative, I won't combine different font families.*” When asked about strategies to combine font families, the designer revealed using external resources: “*If I were to combine different fonts, I would go to a website that you can input the font you are using, and the website suggests a list of other font families that goes well with the one you chose.*” Lastly, high performers affirmed using fonts that they frequently use for designs that are informative and only choosing different or 'artistic' fonts for creative work.

- **Basic formatting.** Participants applied different basic formatting to components with different function (e.g., subtitle and body of text), such as bolded letters, capitalization, and text justifications.

- **Colors.** Most participants expressed not knowing or having difficulties creating a color pallet. One low performer said: “*I don't have a good strategy of which color to use*” and one high performer noted: “*Selecting colors is something I have difficulties with. I mostly follow the brand style guide or search color pallet online*”. Despite both groups expressing difficulty in color selection, the video analysis showed that low performers verbalized choosing colors from the rainbow or default colors in the software, while high performers considered the color wheel. For instance, a high performer purposely used complementary colors (orange and purple in Figure 12) to create color contrast, and another designer chose analogous colors with similar pastel tones (purple, blue, green, and yellow) to create color harmony.
- **Shapes.** In general, all participants added shapes to enclose and create groups, as one high performer noted: "I will add a shape as a box to block each subtopic and make each group distinguishable".

As mentioned earlier, high performers were more thorough and systematic in defining and replicating visual rules. The features worked by only high performers were:

- **Padding.** The space around the text inside the textbox (Figure 21). High performers added white space around any text inside a box, allowing it to 'breath'. Also, high performers dragged guidelines to ensure all paddings were equal, especially the left and right ones.

- **Line and paragraph spacing.** High performers tended to increase the line spacing to make the body of text 'cleaner' and better use the canvas space. Also, high performers paid attention to paragraph spacing by adding bigger space before and after the main title and subtitles and ensuring the space was equal across all groups by dragging baselines in the design (see Figure 21).

![Four design principles for visual composition](image)

Figure 21. Vertical guidelines created to add paddings in the textboxes and baselines created to align elements across the groups
• **Line length.** High performers would determine the column width considering the reading fluency and aesthetic. For instance, they tended to manually break lines to avoid too irregular text rags and widows, as one designer noted: “*We break lines to avoid widows and to make the paragraph look more squared*”. A widow is a lone word that appears at the bottom of a paragraph, and a rag is the uneven side of a paragraph opposed to the side where the text is aligned (Figure 22).

![Figure 22. Examples of a widow and text rags](image)

- **Number of lines.** Another reason high performers would manually break lines was to ensure all paragraphs across the subtopics had the same number of lines. For instance, in Figure 12, the designer purposely broke the line in the second bullet of the Alignment subtopic to ensure all bullet points populated two lines. Additionally, three high performers commented that the amount of text for each subtopic was similar, making it easier to design: “*The amount of text for each subtopic is quite equal, so the text editing also used the repetition principle, making my work easier*”.

- **Kerning.** The space between characters in a word. High performers considered increasing the kerning in the main title and subtitles.

- **Precise alignment and proportion.** High performers often fixated on precise alignments and proportions. The three most common strategies for alignment were: (1) creating a grid, (2) dragging guidelines, both discussed earlier, and (3) aligning and grouping objects and aligning grouped objects. For instance, in Figure 12, a high performer aligned each icon with an orange circle shape in both vertical and
horizontal axles and grouped each pair. Next, she top-aligned all the grouped pairs and left-aligned each group to its respective paragraph. Further, two high performers mentioned using proportions. One designer affirmed that he often types math equations, such as ‘X/2’ or ‘X*2’ to obtain a shape half or twice the size of an existing shape: “I input the math equation, and the software creates the shape with the proportion”. Another feature cited by designers was selecting multiple objects and inputting a specific measurement (e.g., 20 pixels) to get an exact distance between the objects. Despite not having those features (i.e., inputting math equations and measurements), all designers dedicated time and effort to building proper alignment.

6. Testing, adjustments, and validating

After setting a structure and defining and replicating visual rules, high performers duplicated the design to test different colors, fonts, and graphics while maintaining the overall structure and hierarchy (Figure 23). One noticeable strategy executed by a high performer was testing the new design decisions in only two subtopics, then validating the design to decide whether she should continue investing in the new design.

Also, high performers were more prone to scan the overall design, make minor adjustments, and confirm whether the adjustments fit. They often ‘stepped out’ to validate the overall design by leaning back on the seat, turning the grid on and off, zooming out the design, and releasing their hold of the computer mouse. In contrast, low performers tended to look at the overall design to check if they could add or edit any other element to the infographic.

Lastly, high performers tended to make minor adjustments by eyeballing. After arranging all elements on the grid, they would turn the grid on and off, and, based on their assessments of the infographic while working on validation, they would adjust positions and sizes slightly, even if it meant leaving an element off the grid. For instance, in Figure 13, a high performer applied 60% transparency in all textboxes but noticed that the yellow textbox was too light and decided to leave the yellow textbox with 40% transparency. Another example is when high performers used precise sizes (i.e., height) for all icons, turned the grid off, and made adjustments based on the optical weight.
Figure 23. Three options created by a high performer
Visual Design Model

RQ4: What is the resulting visual design model based on observations and comparisons of the processes employed by graphic design experts and non-design college students to generate higher versus lower quality infographics?

The Infographic Visual Design Model (Figure 24) was founded based on the results of this study. More precisely, the five stages in the model are proposed based on the identified visual design processes in the triangulation of multiple data sources. The order of the stages is set based on the results from the sequential and transitional probabilities between the processes. Lastly, the sub-stages are proposed based on the comparative analysis between high and low-performers from the transcribed think-aloud protocols and video content analysis. The resulting model builds on the model proposed by Nuhoglu Kibar & Akkoyunlu (2017), particularly regarding the visual design dimension – the part of the design process that has been recurrently found to be a performance gap identified in prior studies.

Figure 24. Infographic Visual Design Model

The Infographic Visual Design Model consists of five iterative stages: (1) create structure and grid, (2) establish visual hierarchy, (3) define visual rules, (4) replicate visual rules, and (5)
test, validate, and revise. See below recommendations in each stage based on the results from the comparative analysis.

Create Structure and Grid

The structure and grid stage is performed first in the visual design process to encourage a breadth-first process, assisting designers in creating higher-quality infographics. These processes can be implemented by tentatively laying out the components over a grid and working iteratively on visual hierarchy before working on fonts, colors, and graphic elements.

The common steps in this stage include:

1. **Define image dimensions based on publication media.** For instance, a square infographic is suitable for an Instagram post, a portrait infographic fits better in an Instagram story, and a landscape infographic could be ideal for a presentation.
2. **Define margins.** Margins create a safe and breathable space around the design, especially when working with printed media.
3. **Define columns and rows.** The designer may choose the number of columns and rows based on the content. For example, content with four subtopics could fit in a layout of 2 columns by 2 rows, 4 columns, etc.
4. **Define gutters.** Gutters support the proximity principles by spacing apart subgroups to make the distinction visually noticeable.

Establish Visual Hierarchy

The second stage of establishing visual hierarchy comprises working on spatial zones, white space, and font sizes and weights. In general, designers can:

1. **White space.** Add significant white space around the main title.
2. **Proximity.** Place related content near each other and less related content spaced apart to spatially organize and structure the content.
3. **Font size.** Apply different font sizes to create a visual hierarchy. For instance, incrementing 8 pts as the hierarchy moves upwards (e.g., incrementing 8 pts from the subtitle to the main title).
4. **Formatting.** Apply different formatting such as font weights (i.e., bold, italic, etc.), kerning, and capitalization.
Define Visual Rules

High performers used a more *top-down* strategy to define visual rules for one unit of information that visually distinguishes the informational unit from the other units before replicating the visual rules to the remaining units. The visual rules included:

1. **Font family.** Based on the results of this study, designers can use up to two font styles and opt for legible fonts over decorative fonts.
2. **Colors.** Designers can use external resources to select a color pallet or consult the color wheel. For instance, complementary colors might yield more contrast, and analogous colors create more harmony.
3. **Shapes.** Designers may add shapes to create a box or background to the subgroups of the infographic and emphasize the structure and organization.
4. **Paddings.** Designers should consider paddings when creating text boxes.
5. **Line and paragraph spacing.** Designers may increase the line and paragraph spacing to create a cleaner layout and better distribute the content.
6. **Line length.** Designers should consider the line length for reading fluency and aesthetic and avoid widows in paragraphs.
7. **The number of lines.** Designers may break lines to make adjacent paragraphs contain the same number of lines.
8. **Kerning.** Designers may increase kerning to customize titles and subtitles.

Replicate Visual Rules

The replication of visual rules tended to follow two possibilities:

1. **Apply the same characteristics to related content.** For instance, the subtitle, icons, and textbox under the topic Contrast are blue, and the subtitle, icons, and textbox under the topic Alignment are green (Figure 13).
2. **Apply the same characteristics to elements with the same function and hierarchy.** For example, all subtitles are purple, all icons are purple and enclosed in an orange circle, and all bullet points are purple (Figure 12).
Test, Validate, and Revise

The fifth stage includes three steps:

1. **Test different colors, fonts, and graphics while maintaining the overall structure and hierarchy.** After setting the structure and visual hierarchy, designers may duplicate their work to test different colors, such as creating one option with a colored background and another with a white background, or adding graphics and images without making major changes to the overall structure.

2. **Step out to validate the overall design.** Designers should step out, such as looking at the work from a different angle or distance and turning the grid on and off to validate the overall composition.

3. **Adjust based on the optical weight.** Designers should adjust sizes and positions based on the optical weight. For instance, Shestopalov (2017) recommended considering the optical weight instead of geometrical values. The author exemplifies that when a square and a circle with the same height and width are side by side, the square outweighs the circle. In contrast, if we slightly increase the size of the circle, they will look visually balanced, even though they have different heights and widths.
CHAPTER 5
DISCUSSION

Main Findings

This case study examined how graphic designers and non-design college students perform the visual design process when applying visual design principles in infographic design. Through triangulation of multiple sources (i.e., transcribed think-aloud, video content analysis, and short interview), this study identified the visual design processes and the different strategies used to create higher versus lower quality infographics rated across 17 design criteria. These results in conjunction with the computed sequential and transitional probabilities between the observed processes were incorporated into a five-stage process model for the visual composition of effective infographics. The resulting model, entitled Infographic Visual Design Model, builds on Nuhoglu Kibar & Akkoyunlu’s (2017) model, especially on the visual design dimension that has been repeatedly found to be a source of difficulty in prior studies (e.g., Fragou & Papadopoulou, 2020; Nuhoğlu Kibar and Akkoyunlu, 2018; Yuruk et al., 2019)

Visual Design Processes

The findings from the triangulation of multiple data sources (think-aloud protocol, video content analysis, and short interviews) revealed six visual design processes: (1) create structure and grid, (2) establish visual hierarchy, (3) define visual rules, (4) replicate visual rules, (5) test and adjust, and (6) validate and revise. These design processes are consistent with those identified in the pilot study (Kuba & Jeong, 2023). However, this study revealed a new design action - duplicating the slide to test new colors or graphic elements without changing the structure. In the pilot study, participants completed their infographic in JMap (Jeong, 2020b), which did not provide the ability to duplicate slides. In this study, participants (mainly high performers) used PowerPoint, which allowed them to duplicate slides for testing.

Although this study included this new design action (categorized under the Test and Adjust design process), the percentage of time performing the Test and Adjust design process among the high performers in this study was not statistically different from the high performers in the pilot based on Chi-square testing. This finding suggests that high-rated infographics are built through a process in which one-third of the time is dedicated to setting a structure and grid and establishing visual hierarchy, another one-third to defining and replicating visual rules, and
the other third to testing new designs and validating design decisions. Moreover, the percentage of time for each design process statistically differed between high and low performers, similar to the pilot study (Kuba & Jeong, 2023).

In both studies, the most significant difference in percentage time between high and low performers was in the design process of Replicating Visual Rules, which is linked to the repetition principle. High performers, who received the highest score for repetition, applied this principle by creating a visual scheme for one informational unit (i.e., one sub-topic, such as contrast) and then replicating the scheme to the other units (i.e., repetition, alignment, and proximity). Low performers in both studies repeated few formatting for all information units, such as color, font type, and font size, but not details such as alignment and distances, and some even applied different styles for each information unit, resulting in inconsistent designs. These findings support Fragou and Papadopoulou’s (2020) and Pole and Parashar’s (2020) findings that unacceptable infographics lacked consistency, resulting in poor content organization.

The results from the sequential and transitional probabilities between the processes were comparable between this study and the pilot study (Kuba & Jeong, 2023). In general, high-rated infographics were produced using more structured visual design processes, commencing with working on the structure and grid and establishing a visual hierarchy. Afterward, high performers in both studies worked on defining and replicating visual rules, followed by testing and adjustments, and validation. Moreover, the transitional probabilities between the processes for high-rated infographics in this study revealed three iterative processes: Structure ↔ Visual Hierarchy, Define Visual Rules ↔ Validation, and Test and Adjust ↔ Validate. The first and third iterations were consistent with the pilot study, but the second was not observed. It is possible that high performers in this study more frequently moved back and forth between defining visual rules and validation as they tested new designs by duplicating the slide and define new rules to accommodate the new designs – a possibility not available for participants in the pilot study, as mentioned earlier.

Lastly, similar to the pilot study, the transitional probabilities between the processes in low-rated infographics revealed a less iterative design process and patterns. These results and the triangulated data indicate that low performers tended to work on fonts, colors, and graphics as they placed a new element on the canvas instead of positioning and organizing all elements before working on details – consistent with findings from the pilot study. These findings are in
line with Aguilar and Correia's (2017) study that planned structure is connected to high-quality work as well as Bae and Watson's (2014) study that showed that information is more effectively communicated when it is organized and structured using design principles.

**Visual Design Strategies that Separate High from Low Performers**

To identify the unique strategies used to produce the high-quality infographics versus low-quality infographics, a comparative analysis was conducted between observations of high and low-performers from the transcribed think-aloud protocols and video content analysis. This analysis revealed six major visual design strategies – where five of these six strategies (strategies 1, 2, 3, 5 and 6) were used more often by high performers than the low performers:

1. Define image dimensions based on publication media
2. Breadth-first over depth-first approach
3. Build a grid to structure a layout
4. Use spatial zones and typography to establish a visual hierarchy
5. Define and replicate visual rules
6. Test, adjust, and validate

**Define image dimensions based on publication media.** The strategy of defining image dimensions based on the publication site is a new finding that was not uncovered in the pilot study (Kuba & Jeong, 2023). Two high performers mentioned considering the publication site in their decision on choosing the format, such as selecting a wide landscape format for presentation and a portrait format for a smartphone screen.

**Breadth-first over depth-first approach.** The second strategy suggests that designers can create higher quality infographics by using a breadth-first approach by laying out the elements over a grid and working on visual hierarchy prior to working on fonts, colors, and graphic elements, consistent with findings that the breadth-first process is associated with better concept maps (Jeong, 2020a).

**Build a grid to structure a layout.** High performers in the pilot (Kuba & Jeong, 2023) and this study stated setting a grid to define the structure and using the grid for aligning elements. They
tested layouts according to the content, such as building a grid with four columns for a text that included four topics. The settings in grid construction were margins, columns, rows, and gutters. The latter was also used in support of the proximity principle. High performers increased the size of the gutters to create meaningful groups based on the message (e.g., spacing apart the four subtopics to visually convey a structure of four informational units), creating a clear structure to help viewers understand the components’ connection. At the same time, the elements within a subtopic would be placed closer to each other to form a sense of unity. These strategies echo Mayer’s (2017) contiguity principle that effective multimedia materials present corresponding contents near one another.

One strategy performed by two low performers in this study and two in the pilot study was positioning and formatting the main title or all icons in the middle of the screen, creating a hub-and-spoke infographic with text extending in all directions. Low performers who created hub-and-spoke infographics spent more time composing the infographic since some formatting did not work equally for all information units. For instance, aligning text on the left only worked for the units on the left side since those on the right side would be impacted by the title located in the center of the infographic. In general, researchers agree that hub-and-spoke diagrams have poor reading flow and are more disorienting (Aguiar & Correia, 2017; Jeong & Lee, 2012). Thus, infographics organized in a hub-and-spoke format had lower scores than infographics presenting the reading flow in a top-down and left-to-right structure, consistent with Jeong and Lee’s (2012) findings that hub-and-spoke diagrams are harder to process.

**Use spatial zones and typography to establish a visual hierarchy.** Using font size based on the significance of the information was a strategy applied by all participants, supporting Kane’s (2018) and Pole and Parashar’s (2020) assertion that visual hierarchy based on using font sizes for different purposes is essential to guide learners through the message and unclear hierarchy makes the information difficult to discern. Apart from font sizes, participants used different formatting to create a visual hierarchy with the goal of creating contrasting formatting between elements (e.g., formatting a title that visually distinguishes from the subtitles). These results suggest that the contrast principle can be associated with effective visual hierarchy (Kuba, 2021).

**Define and replicate visual rules.** High performers used a more top-down approach to define visual rules (font, color, graphics, spacing) for a particular informational unit that visually
differentiates it from others (for example, subtitles that all share similar characteristics), then replicated the rules in the other informational units. High performers spent less time defining visual rules than low performers, which was also true in the pilot study (Kuba & Jeong, 2023), possibly because they tended to use font families and colors that they were accustomed to and had previously used in other projects. High performers also maintained the design simple by selecting no more than two font families and adding graphics, such as shapes, to emphasize content structure rather than decorate the design, which is another noticeable pattern observed in this study and pilot study. For instance, they would place boxes around each subtopic to further distinguish and provide a visual cue of the content consisting of four subgroups. Such tactics support Kane's (2018) advice to choose legible fonts over ornamental ones and simple visuals over complex ones, as well as Tomita's (2017) recommendation to restrict the usage of various font families.

The visual rules defined and replicated by all participants in this study included font family, bolded letters, capitalization, text justifications, colors, and shapes. The visual rules worked only by high performers included padding, line and paragraph spacing, line length, number of lines, kerning, and precise alignment and proportion. Since high performers were more strict in replicating visual rules and also had more rules to replicate, they spent more time in this design process than low performers, similar to the pilot study (Kuba & Jeong, 2023). Another notable strategy was applying the same characteristics, such as colors, to related content (e.g., all elements within a unit) or elements with the same function and hierarchy (e.g., all subtitles). These results corroborate those of Fragou and Papadopoulou (2020) and Pole and Parashar (2020), who found that good infographics used colors to group semantic information, while bad infographics lacked consistency, leading to disorganized content.

**Test, adjust, and validate.** Under this strategy, there were three notable tactics. First, high performers cloned the design (i.e., duplicated the slide) to test various colors, fonts, and graphics while preserving the overall structure and hierarchy. Second, high performers often took a step back to assess the overall design by reclining back on the seat, turning the grid on and off, zooming out the design, and letting go of the computer mouse, which supports Sosa's (2009) advice. Third, in line with Shestopalov's (2017) recommendation, high performers made any necessary final modifications based on the optical weight, such as evaluating the visual weight.
rather than geometrical parameters. Shestopalov (2017) exemplifies that when a square and a circle of the same height and width are placed next to one another, the square appears bigger than the circle. Instead, designers can increase the size of the circle to make the circle and square appear aesthetically balanced by having a similar area. The two last tactics were also observed in the pilot study (Kuba & Jeong, 2023), but the first was not possible given the software limitation.

**Visual Design Model**

The Infographic Visual Design Model (Figure 24) consists of five iterative design stages: (1) create structure and grid, (2) establish visual hierarchy, (3) define visual rules, (4) replicate visual rules, and (5) test, validate, and revise. The stages represent the visual design processes identified in the triangulation of multiple data sources, and the order is set based on the results from the sequential and transitional probabilities between the processes. These first four stages are consistent with the stages identified in the pilot study (Kuba & Jeong, 2023), but the fifth stage comprises testing, a new process determined in this study. Thus, the revised model includes a sub-stage related to testing new options under the Test, Validate, and Revise stage.

The model starts with the structure and grid stage to promote a breadth-first approach across informational units, including determining format, setting margins, and creating a modular grid with columns, rows, baselines, and gutters based on the content structure. Working on spatial zones, white space, and font sizes and weights constitute the second stage in establishing a visual hierarchy. In this stage, the goal is to create contrasting formatting, such as different font sizes, based on the importance of the information. Also, the results on the utilization of spatial zones and white space in the grid are consistent with other studies indicating that spatial zones strengthen hierarchy (e.g., Timothy, 2017) and that white spaces can enhance comprehension by giving important elements more breathing room and emphasis (Pole & Parashar, 2020).

The third stage is defining visual rules, which include choosing colors, adding graphic elements, and styling fonts. In this stage, designers can work in a top-down approach by defining visual rules for elements in the composition (e.g., defining formatting for titles and subtitles) before replicating the design decisions to analogous information (e.g., replicating formatting for the remaining titles and subtitles). In replicating visual rules, designers can apply similar characteristics, like colors and styles, to related content or content with similar functions and hierarchies. Lastly, testing, validating, and revising comprise the last stage in the Infographic
Visual Design Model. In the last stage, designers may test other designs, such as applying different colors and shapes, while preserving the overall structure. Also, as the designer test and adjust the design, they may step back to examine the overall composition and make adjustments based on the optical weight.

Overall, the findings extend on and builds our understanding of applying visual design principles more effectively by using higher-level strategies and macro processes in visual compositions. This study describes and explains six design actions that are used to produce infographics that provide clear and meaningful information while also being aesthetically pleasing. The design process for creating infographic has been described as complex since it requires multiple criteria to be applied simultaneously related to content creation, visual design, and typography (Yuruk et al., 2019). Second, the Infographic Visual Design Model supplements Nuhoglu Kibar & Akkoyunlu’s (2017) model on infographic design, targeting the visual design dimension since participants worked with a ready-to-use text to control for the content generation dimension and used the same design tool to control for the digital design dimension.

Nuhoglu Kibar & Akkoyunlu’s (2017) model presents a conceptual framework including three dimensions (content, visual design, and digital design dimension) in designing infographics, stages such as generating the content, followed by generating drafts and visual design, and criteria for assessing infographics. The model in this study adds to their model by identifying specific strategies (e.g., using spatial zones to establish a visual hierarchy) and processes (e.g., setting a structure before working on details) that support learners in the visual design dimension and visual design stage and meeting visual design criteria (i.e., specified in the Infographic Design Rubric). Nevertheless, addressing the visual design dimension shed light on potential strategies that can be prescribed to help individuals perform design tasks, often reported as challenging for adults and young students.

**Supplemental Findings**

In this study and the pilot study (Kuba & Jeong, 2023), high performers included graphic design experts and had over two-thirds of their rubric items scored as competent or exemplary. Low performers in both studies had almost all items scored as unacceptable or needing work. Note that low performers in this study were all non-design college students who had never taken any visual design class. In the pilot study (Kuba & Jeong, 2023), low performers included
instructional designers and one graphic designer who all had taken visual design classes. These results back studies showing that adults and students from non-design fields lack visual design skills (Brumberger and Northcut, 2016; Fragou & Papadopoulou, 2020; O’Mahony et al., 2019).

Further, the average time completion for high performers in this study was 46 minutes, and 31 in the pilot study. However, the greatest difference was in the time for low performers. Those in this study spent an average of 32 minutes, while low performers in the pilot study spent around 90 minutes completing their infographics. Non-design students tended to finish the infographic within 15 minutes and then mentioned not knowing what to do next to make the design appealing. Most students stated relying on built-in design themes, in which they add the content in the placeholders. This excessive dependence on themes might have prevented students from in-depth thinking about visual design and techniques to create appealing designs. This finding supports studies that exploratory environments, such as open-task with multiple solutions, can be challenging for students with low prior knowledge (Kirschner et al., 2006; Moreno & Mayer, 2005; Yang et al., 2021) and, especially for visual design skills, students need more explicit instruction (Nuhoğlu Kibar & Akkoyunlu, 2018). However, despite not being able to use themes, students expressed enjoying the design task and wanting to learn more about visual design, echoing studies (e.g., Bratslavsky et al., 2019; Sosa, 2009; Stoerger, 2018; VanderMolen & Spivey, 2017) that showed students enjoyed the creative challenge and found designing to be fun and engaging.

In contrast, the low performers in the pilot study (Kuba & Jeong, 2023) knew the possibilities and applied as many features as possible, which may explain the high average time completion. They added more shapes, fonts, and ornaments and frequently wanted to use advanced effects such as shadows and fading. The comparison between low performers in the pilot and this study supports studies indicating that students with high prior knowledge are more ready to apply the knowledge than peers with low prior knowledge (Chen et al., 2014a; Yang et al., 2021). Also, knowing advanced features in digital tools does not necessarily imply the ability to create effective visual communication products.

Lastly, findings from this replication study, in conjunction with the pilot study (Kuba & Jeong, 2023), advocate that students with no prior knowledge of visual design need formal lectures and instructions on visual design, such as colors and design principles, as mentioned by Abas (2019) and Nuhoğlu Kibar and Akkoyunlu (2018). According to researchers (e.g., Abas,
2019; Catanzaro & Collin, 2021), the ability to interpret and create visuals does not develop unless the skills are taught, supported, and integrated into the curriculum. In sum, the increased propagation of visual does not guarantee that non-designers have understood and effectively created a message being delivered and educators cannot presume that individuals already have the abilities to be visually literate (Avgerinou, 2009).

**Instructional Implications**

The Infographic Visual Design Model is a procedural model for creating higher quality infographics in terms of using grids/layout, colors, shapes, and typography and offers practical instructions on producing visual messages for both learning and teaching visual communication skills. Studies have indicated that students lack the ability to apply design principles (e.g., Fragou & Papadopoulou, 2020), do not have a clear framework for producing visuals (Chen et al., 2014b), and current models lack procedural guidance in the visual design stage (e.g., Nuhoğlu Kibar & Akkoyunlu, 2015). With the goal of addressing the above issues, the model has the potential to help students think more deeply about visual communication, encouraging them to make contextualized and purposeful design decisions to communicate more effectively through visual representation instead of following prescriptive guidelines (e.g., checking off items of dos and don'ts, that are usually oversimplifications that hardly account for variations). According to PISA (2019), designing infographics help students engage in an open visual design task, learn digital tools, and develop visual design ideas according to the scenario and stimuli specified in the task. In addition, the model can be used as a learning tool to encourage students to identify the strategies applied in well-designed visuals and facilitate discussion on design processes by deconstructing a well-designed visual based on the reverse steps of the model.

At the same time, the visual design model can serve as a guide to assist teachers in assessing their students’ visual communication skills in regard to their ability to generate diverse ideas and represent information in different ways. Furthermore, the model can help teachers from diverse fields and instructional designers develop high-quality infographics that can be used in different areas such as education, scientific research, and engineering to attract and inform audiences (Lan et al., 2021), boosting the power of infographics for learning (Alqudah et al., 2019; Alsadoun, 2021) achievement motivation (e.g., Ibrahem & Alamro, 2021), affective responses (Lan et al., 2021), and collaborative learning (Nuhoğlu-Kibar et al., 2019).
The specific strategies and visual design process identified in the this study’s model can ultimately be implemented and embedded directly into graphics software to provide users with real-time guidance on the design process. Additionally, graphics software can be developed to apply data mining and learning analytics to identify the strategies users are using and deliver real-time interventions that promote the use of the desired strategies and discourage actions that stray away from the desired strategies. For example, the jMAP software used in the pilot study possesses an algorithm (still in development) that can identify to what extent students are using the bread-first and depth-first strategy. Future graphic software can also be designed to identify the gaps in students’ knowledge and skills in visual design found in in this study – gaps that relate specifically to design principles concepts, grid construction, color pallet composition, and font selection for organizing content and conveying data and knowledge in infographics.

**Limitations**

The current study examined the visual design process of graphic and instructional designers in composing infographics and investigated the various strategies used to generate high and low-quality infographics. The examination resulted in a procedural model for infographic visual composition (i.e., Infographic Visual Design Model) concerning the visual design dimension in the IDM (Nuhoglu Kibar & Akkoyunlu, 2017). However, the study has limitations to consider. The study included a small sample size (i.e., ten participants), and all low performers included college students in the US with no prior course in visual design. Thus, careful consideration is needed for generalizing findings outside of this study’s audience. Also, the design task included some constraints: (1) participants had a short time to design the infographics, (2) were observed and recorded during the entire task, (3) were not allowed to use external resources or insert additional images, and (4) were also asked to use a presentation design tool that had limited functions compared to professional design tools. Those constraints were necessary for a more controlled research environment but reduced a natural setting. Lastly, this study targeted the visual design dimension exclusively with content and images provided in advance, and thus, the findings in this study may not necessarily generalize to or be applicable to the design and evaluation of infographics when students’ generate their own content and images.
Directions for Future Research

The findings presented in this study expand the discussion on improving visual design skills for non-design individuals by proposing a procedural model and strategies to guide them in applying design principles. Further research can replicate this study with larger sample sizes and examine the effectiveness of the Infographic Visual Design Model and specific design strategies, such as using a breadth-first approach and creating modular grids. Researchers can conduct controlled experiments to investigate the efficacy of implementing the Infographic Visual Design Model for improving the quality of infographics and potentially other visual communication products across a wide range of learners and academic fields with varying levels of prior knowledge on design principles. Furthermore, controlled experimental studies can determine to what extent non-design individuals (or individuals with little or no prior knowledge or experience with visual design) are able to perform the steps identified in the model and whether additional steps or pre-requisite knowledge (not readily tangible from observing the experts in this study) is necessary to enable such individuals to apply the model with high fidelity.

Additionally, future research may consider collecting qualitative data to examine the usability of the model, such as analyzing students’ perceptions of the model and teachers’ perceptions of using the model in classrooms. Researchers may further investigate the design processes of design experts in a more natural setting (i.e., with minimum manipulation of the environment), in which they can use external resources and software of their preference. According to Creswell and Poth (2018), qualitative researchers should gather data at the site where participants experience the phenomenon and observe people behave within their context.

Furthermore, this study also addresses calls (e.g., Brumberger, 2019; Richey & Klein, 2009) to research into ‘expert’ and ‘novice’ visual design behaviors, helping identify current students’ knowledge and skills in visual design. According to Brumberger (2019), research into ‘expert’ and ‘novice’ can help identify how well a student has mastered specific skills. Thus, researchers may test the Infographic Visual Design Model as an assessment tool to help teachers identify the stages that students are struggling with and provide further instructions and support. At the same time, researchers can also test the model as a self-checking tool to help students better comprehend their progress and areas for improvement. In addition, researchers can develop and test learning supports such as job aids to scaffold students in each part of the model.
Lastly, the findings, methods, and data analysis may help advance research on visual communication, a topic that intersects many disciplines (Brumberger, 2014), boosting the contributions to many areas and practices. Brumberger (2019) states that there is little research examining research methods on visual communication. This study may provide insights into ways of exploring visual design, such as controlling for content and tools, determining actual design processes, and understanding the different strategies used by participants of varying levels of expertise and fields ranging from architecture and product design to engineering programs.

In conclusion, students from wide-ranging fields will need to apply visual design skills in the future, such as conveying information visually (VanderMolen & Spivey, 2017). Additionally, this and previous studies corroborate that students enjoy creating visuals and find the creative process to be fun and engaging, suggesting that students might have the necessary motivation to improve such skills if provided with proper instruction (Bratslavsky et al., 2019; Sosa, 2009; Stoerger, 2018; VanderMolen & Spivey, 2017). Thus, I hope this study helps increase interest in visual design in both research and education curriculums to empower students with skills to communicate visually, helping them succeed in their future and career field.
APPENDIX A
MULTIMEDIA LEARNING MATERIAL

1

CONTRAST

Create contrast by arranging opposite elements in a composition, drawing viewers’ attention to specific elements.

(Williams, 2008, p. 219)

For example:

Hello World!
Hello World!

These two fonts have similar characteristics. They look the same even though they are not.

Hello World!
Hello World!

If two elements are not the same, make them very different!

(Williams, 2008, p. 220)
HOW TO APPLY CONTRAST

- If you are placing two elements that are not the same (e.g., two fonts), make them very different.
- Contrast colors, shapes, sizes, white space, thickness, etc.
- Use different font sizes for different purposes.

Color contrast
Size contrast

(Williams, 2008, p. 220)

For example:

The title has a different font size and color to contrast with the body of the text.

The bolded letters highlight important keywords.

VIRTUAL REALITY

Applications that generates realistic images, sounds and other sensations to represent an immersive environment and simulate a user's physical presence in that environment.

The system:
- creates an entire virtual world.
- simulates a user's physical presence.
- can provide a real-time interaction.
2

REPETITION

Elements that share similar characteristics are perceived as related, while the lack of pattern indicates that they are unrelated.

(Williams, 2008, p. 777)

For example:

If we see these people walking on the street, their relationship is unclear. Are they related?

Now the similarities of them make it clear there is a relationship between them.
HOW TO APPLY REPETITION

- Repeat some aspects of the design throughout the entire piece.
- Apply the same characteristics to elements that are related (e.g., same topic) or have the same function (e.g., subtitles).
- Use colors to form patterns.

For example:

In this design, the elements with the same function have the same characteristics:

- Icons are outlined and green.
- Subtitles are dark gray.

PRINCÍPIOS DA GESTÃO DE RISCOS

Como é a estrutura da gestão de riscos?

- Integrada: É parte integrante de todas as atividades organizacionais.
- Estruturada: É estruturada e abrangente, contribuindo para resultados consistentes e comparáveis.
- Personalizada: É personalizada e proporcional aos contextos da empresa.
- Inclusiva: Engloba diversos conhecimentos, pontos de vistas e percepções.

Dinâmica: A gestão antecipa, detecta, reconhece e responde a mudanças.
Informada: A informação é oportuna, clara e disponível.
Humana: O comportamento humano e a cultura influenciam todos os aspectos da gestão.
Aprimorada: Melhoria contínua por meio do aprendizado e experiências.
ALIGNMENT

Nothing should be placed on the page arbitrarily. All elements should have some visual connection with another element on the page.

(Williams, 2008, p. 140)

For example:

Both boxes and their headings are aligned to establish a visual connection between them.

Text alignment is equal in both boxes.
HOW TO APPLY ALIGNMENT

- Draw lines between elements to determine where the connections are lacking.
- Avoid using too many combinations of text alignment.
- Use grids to line up elements on the page.

For example:

Draw horizontal and vertical lines to create a grid and help you place elements on the page.

Alignment makes a design look clean and gives your design organization and structure.

[Williams, 2008, p. 80]
PROXIMITY

When several items are in close **proximity** to each other, they become one visual unit rather than several separate units.

(Williams, 2008, p. 78)

For example:

If we see these two walking on the street, their relationship is unclear. Are they related?

Now the proximity of these two people makes it clear there is a relationship between them.

(Williams, 2008, p. 35)
HOW TO APPLY PROXIMITY

- Place related elements together: elements that are close to each other are perceived as related.
- If elements are not related, move them apart from each other.
- Use whitespace to create meaningful groups.

These two groupings are still clear even when we include different shapes within each group.

[Williams, 2008, p. 80]

For example:

Contrast: Establishing Visual Hierarchy

Contrast involves highlighting key content. Studies have shown that bolding text to emphasize keywords helps learners remember the important content (Zwaan, 2012).

- **Font size**: use bold font to highlight the main title and subheadings. Make sure the main title is larger for a clear distinction between the hierarchy of content.
- **Font color**: apply a unique color to main titles to enhance the visual hierarchy.
- **White space**: use white space around the main title or key sentences to help them stand out and draw in the viewer's attention.
- **Columns**: apply columns to the titles and subheadings. You can use the colors of your organizational brand to strengthen and convey your design to the reader visually.
- **Shapes**: alternatively, you can also place small shapes close to key content to make them stand out and direct the reading flow.

Proximity defines groups of related text such as paragraphs and sections.

These groupings are discernible even without viewing the actual text.
APPENDIX B
MULTIPLE-CHOICE ASSESSMENT

1. Which of the scenarios below follow the Contrast principle?
   a) Using two very distinct typefaces in the design.
   b) Using only one typeface in the design.
   c) Using two very similar typefaces in the design.
   d) Combining different and similar typefaces in the design.
   Answer: A
   Feedback: Using two very distinct typefaces in the design is an example of the contrast principle, as arranging opposite or very different elements in a composition creates contrast.

2. Which design principle makes elements that are close to each other look related?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: D
   Feedback: Proximity. When several items are in close proximity to each other, they become one visual unit rather than several separate units.

3. Which of the scenarios below follow the Alignment principle?
   a) Placing elements arbitrarily in the design.
   b) Drawing lines to line up elements in the design.
   c) Combining various text alignments in the design.
   d) Avoiding visual connections between elements in the design.
   Answer: B
   Feedback: Drawing lines to line up elements in the design follows the alignment principle. Nothing should be placed on the page arbitrarily. All elements should have some visual connection with another element. We should avoid too many combinations of text alignment.
4. Applying red color to all subtitles is an example of which design principle?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: B
   Feedback: Repetition states that elements that share similar characteristics are perceived as related. We can apply the same characteristics to elements that are related (e.g., same topic) or have the same function (e.g., subtitles).

5. Using grids to identify where to place elements is an example of which design principle?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: C
   Feedback: Alignment. We can draw horizontal and vertical lines to create a grid and help us place elements on the page.

6. Which design principle makes distinct elements stand out in the design?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: A
   Feedback: Contrast. When we place opposite elements in a composition, we draw viewers’ attention to specific elements. For example, using bolded letters to highlight important key words or sentences.
7. Which of the scenarios below follow the Repetition principle?
   a) Using different colors, styles, and sizes for the headings.
   b) Using the same color, but different style and size for the headings.
   c) Using the same color, style, and size for the headings.
   d) Using similar colors, styles, and sizes for the headings.
   Answer: C
   Feedback: Using the same color, style, and size for the headings. Elements that share similar characteristics are perceived as related (i.e., all headings are related as they have the same function and hierarchy).

8. Spacing apart two sections of text is an example of which design principle?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: D
   Feedback: Proximity. We can use whitespace to create meaningful groups such as moving apart elements that are not related.

9. Which design principle makes elements that share similar characteristics look as they have a relationship between them?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: B
   Feedback: Repetition. Elements that share similar characteristics are perceived as related, while the lack of pattern indicates that they are unrelated. For example, paragraphs on topic A are colored as blue and paragraphs on topic B as purple.
10. Which design principle makes elements look lined up in the design?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: C
   Feedback: Alignment. We can draw lines between elements to determine where the connections are lacking. All elements should have some visual connection with another element on the page.

11. Which of the scenarios below follow the Proximity principle?
   a) Placing related elements far apart in the design.
   b) Avoiding the use of white space to create meaningful groups.
   c) Placing unrelated elements together in the design.
   d) Placing related elements together in the design.
   Answer: D
   Feedback: Placing related elements together in the design. When several items are in close proximity to each other, they become one visual unit rather than several separate units.

12. Using bolded letters to highlight important content is an example of which design principle?
   a) Contrast
   b) Repetition
   c) Alignment
   d) Proximity
   Answer: A
   Feedback: Contrast. When we place a distinct element in a composition, we can draw viewers’ attention to the element. For example, bolded letters stand out among paragraphs with a regular font style.
APPENDIX C
RESEARCH SCRIPT

[say] Hi, ___________. My name is Renata, and I’m going to be walking you through this session today. Before we begin, I have some information for you, and I’m going to read it to make sure that I cover everything.

You probably already have a good idea of why we asked you here but let me go over it again briefly. We’re asking people to perform a design task so we can explore how people use design principles when creating a visual composition.

The first thing I want to make clear right away is that we’re testing ways to improve visual literacy, not you. You can’t do anything wrong here. In fact, this is probably the one place today where you don’t have to worry about making mistakes. As you do the design task, I’m going to ask you as much as possible to try to think out loud: to say what you’re looking at, what you’re trying to do, and what you’re thinking. This will be a big help to us.

If you have any questions as we go along, just ask them. I may not be able to answer them right away, since we’re interested in how people do when they don’t have someone sitting next to them to help. But if you still have any questions when we’re done, I’ll try to answer them then. And if you need to take a break at any point, just let me know.

[say] Do you have any questions so far?

[do] Answer any question.

[say] OK. Before we start the design task, I will ask you to read a presentation to ensure you understand the content you will use to compose the infographic. After reading the material, you will respond to a quick questionnaire about the content you just read. I will send the links in the chat.

[do] Send link to the presentation and assessment in the chat.
https://drive.google.com/file/d/1qT8GxbgQ8C1wZkiiwQc13Xpe22YhAhUa/view?usp=sharing
https://forms.gle/xhrfX5vSxqXHtg9

- - - participants complete reading and assessment - - -

[say] Thank you for completing that part. Now, with your permission, I am going to record what happens on the screen and our conversation. The recording won’t be seen by anyone except the
people working on this project. And it helps me, because I don’t have to take as many notes. Is it ok?

[do] Start recording the session.

I’d like to ask you a few questions before starting the design task.

1. What is your educational background?
2. What is your current occupation?
3. How many years of work experience do you have?
4. Have you taken any visual design class or related class?
5. Have you worked with visual design before? For how long?
6. Can you give me examples of projects that you have to apply visual design skills?
7. If you don’t mind me asking and it is okay if you don’t want to answer, how old are you?

[say] Thank you so much for answering these questions. Now I am going to ask you to watch a quick explaining the design task. I am sending the link in the chat.

[do] Send demonstration video link in the chat.

https://vimeo.com/456411853

[say] Do you have any questions about the task?

OK. We will start the design task now. I will share my screen and give you control.

[do] Share screen and give participant control of the screen.

[say] In this design task, I’m going to ask you to create an infographic using the provided text and icons. I’m also going to ask you to try using the following four design principles listed here. Do you have any questions about the design principles?

[do] Answer any question.

[say] Keep in mind that these guidelines are examples. If you want to apply these principles in different ways, you are welcome to do so. In fact, I would love to hear and see your way of using these principles. That said, remember that you have all these options here such as changing font and colors.

Also, remember that using the provided shapes is optional, but all text and icons must be included. Finally, I’m also going to ask you to do the task without using external resources. We’ll learn a lot more about how people create visual compositions that way. We are going to spend the last 45 minutes on this task. But, please, do not rush and try your best to create an appealing and readable
infographic! If you don’t like your first trial, you can edit as many times as you want until you are satisfied with your work.
And again, as much as possible, it will help us if you can try to think out loud as you go along. For example, tell me what you are seeing, what you are planning to do, what you are trying to do, etc.

- - - participants perform design tasks - - -

[say] Do you have any questions for me, now that we’re done?
[do] Answer any question.
[say] Ok. Can you walk me through how you used the design principles?
Have you worked using a grid before? If yes, how do you usually create and use the grid? How important is the grid in your design process?
[do] Stop the screen recorder and save the file.
Thank you so much for your participation.

**Prompting Questions**
I see that you started creating your infographic, what is your idea or what are you trying to do?
Can you share what you are doing now?
What is your thought on your work now?
What do you think your next moves should be?
How do you feel about your work at this point?
## APPENDIX D

### ADAPTED VERSION OF THE INFOGRAPHIC DESIGN RUBRIC

**Big-Picture Sub-Dimension**

<table>
<thead>
<tr>
<th></th>
<th>Unacceptable (1)</th>
<th>Needs work (2)</th>
<th>Competent (3)</th>
<th>Exemplary (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hierarchy</strong></td>
<td>No visual hierarchy between the components is present or the hierarchy formed causes confusion.</td>
<td>Components form a certain visual hierarchy.</td>
<td>Components form a visual hierarchy consistent with the semantic grouping of information.</td>
<td>Components form a visual hierarchy consistent with the semantic grouping of information and significance of the information.</td>
</tr>
<tr>
<td><strong>Emphasis</strong></td>
<td>No emphasis is made and a focal point is not present.</td>
<td>Fundamental portions of the information within the context are highlighted.</td>
<td>Fundamental information within the context is highlighted and a focal point is created.</td>
<td>Fundamental information within the context is highlighted and the focal point is created based on the main message in the content.</td>
</tr>
<tr>
<td><strong>Contrast</strong></td>
<td>No contrast is made and it is difficult to read or distinguish components.</td>
<td>The infographic is readable and components have a certain contrast.</td>
<td>The infographic is easy to read and it is easy to distinguish components, but the infographic lacks dynamism.</td>
<td>The infographic is easy to read, distinct components stand out, and there is a sense of dynamism on the infographic.</td>
</tr>
<tr>
<td><strong>Repetition</strong></td>
<td>No repetition is made and there is no sense of unity and consistency.</td>
<td>There are some design repetitions and a certain sense of unity but without a complete consistency.</td>
<td>Design repetitions create a sense of unity and consistency but do not provide visual cues of how the content is organized or how the components fit together.</td>
<td>Design repetitions create unity and consistency and provide visual cues of how the content is organized and how the components fit together.</td>
</tr>
<tr>
<td><strong>Alignment</strong></td>
<td>No alignment is made and components are positioned arbitrarily.</td>
<td>There is a certain alignment within components.</td>
<td>Components are organized on the page and have some connections with each other.</td>
<td>Components are organized on the page and have connections with each other making the infographic clear and organized.</td>
</tr>
<tr>
<td><strong>Proximity</strong></td>
<td>The proximity between elements is arbitrary.</td>
<td>Some related components are spaced apart or some unrelated components are placed together.</td>
<td>The proximity between elements is based on the message (related components are placed together and unrelated are spaced apart).</td>
<td>The proximity between elements is based on the message and the infographic has a clear structure that helps understand their connection.</td>
</tr>
<tr>
<td><strong>Balance</strong></td>
<td>No balance is made and the lack of balance creates a vague discomfort.</td>
<td>Components are arranged in a fashion that creates a balance between the text, visuals, but white space is ignored.</td>
<td>Components are arranged in a fashion that creates balance between the text, visuals, and white space.</td>
<td>Components are arranged in a fashion that creates a balance between the text, visuals, and white space and provides a sense of equilibrium and equal distribution of visual weight.</td>
</tr>
</tbody>
</table>
### Design Component Sub-Dimension

<table>
<thead>
<tr>
<th></th>
<th>Unacceptable (1)</th>
<th>Needs work (2)</th>
<th>Competent (3)</th>
<th>Exemplary (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Font Type</strong></td>
<td>The font is not legible.</td>
<td>Fonts are legible, however, variety of fonts has a negative impact on readability.</td>
<td>Legible fonts are used and readability is achieved by selecting a maximum of two fonts matching each other.</td>
<td>Legible fonts are used and readability is achieved by selecting a maximum of two fonts matching each other and congruent with the content.</td>
</tr>
<tr>
<td><strong>Font Color</strong></td>
<td>Font color is not distinguishable from the background.</td>
<td>Font color is distinguishable from the background but creates a vague discomfort.</td>
<td>The choice of font color takes the relationship between text and background into account to increase readability.</td>
<td>Choice of font color takes into account the relationship between the text and background and the congruency with the content in an attempt to increase readability.</td>
</tr>
<tr>
<td><strong>Font Size</strong></td>
<td>Font size is large enough to read although the variety of font sizes has a negative impact on readability.</td>
<td>Font size is large enough to read and the variety of font sizes has a positive impact on readability.</td>
<td></td>
<td>Font size is large enough to read and different font sizes have been used corresponding to the content.</td>
</tr>
<tr>
<td><strong>Font Case</strong></td>
<td>The use of upper-lower case letters has a negative impact over readability.</td>
<td>The use of upper-lower case letters positively supports readability.</td>
<td>The use of upper-lower case letters increases the dynamism of the text.</td>
<td>The use of upper-lower case letters increases the dynamism of the text and is consistent throughout the infographic.</td>
</tr>
<tr>
<td><strong>Line Length</strong></td>
<td>Line lengths / column widths have a negative impact over readability (longer or shorter than the usual).</td>
<td>Line lengths / column widths positively support readability.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Line Spacing</strong></td>
<td>Spacing between lines has a negative impact over readability (narrower or wider than the usual).</td>
<td>Spacing between lines positively supports readability.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Justification</strong></td>
<td>The justification method has a negative impact on readability.</td>
<td>The justification positively supports readability.</td>
<td>The justification is adequate for easy perception and smooth reading fluency.</td>
<td>The justification method is adequate for easy perception and smooth reading fluency and is consistent throughout the infographic.</td>
</tr>
<tr>
<td>Color Effect on Visibility of Information</td>
<td>Unacceptable (1)</td>
<td>Needs work (2)</td>
<td>Competent (3)</td>
<td>Exemplary (4)</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>--------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Colors have a negative impact on legibility, readability and visibility of the information.</td>
<td>Colors positively affect legibility and readability.</td>
<td>Colors promote the relaying of the content to the reader more than being simply a decoration.</td>
<td>The use of colors enables coding through assignment of certain colors to certain components.</td>
<td></td>
</tr>
<tr>
<td>The colors clash with each other and form a complicated structure.</td>
<td>The colors are harmonious but are too distractive.</td>
<td>The colors make up a harmonious palette and diversity is obtained through selection of different color tones.</td>
<td>The color palette of harmonious colors is congruent with the content and diversity is obtained through selection of different color notes.</td>
<td></td>
</tr>
<tr>
<td>The background pattern and color has a negative impact on legibility and readability.</td>
<td>The background pattern or color positively supports legibility and readability.</td>
<td>A plain background with no pattern and with light colors draws the attention to the text and visual components.</td>
<td>A plain background with no pattern and with light colors draws the attention to the text and visual components and the fields left blank allow the reader to rest.</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Nuhoğlu Kibar & Akkoyunlu, 2017.
APPENDIX E
IRB APPROVAL NOTICE

FLORIDA STATE UNIVERSITY
OFFICE of the VICE PRESIDENT for RESEARCH

EXEMPTION DETERMINATION

October 27, 2022

Renata Kuba Kamikabeya, 850-644-5260
rk18d@fsu.edu

Dear Renata Kuba Kamikabeya:

On 10/27/2022, the IRB staff reviewed the following submission:

<table>
<thead>
<tr>
<th>Type of Review:</th>
<th>Exempt</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3)(i)(B) Benign behavioral interventions (low risk)</td>
<td></td>
</tr>
<tr>
<td>Title:</td>
<td>Sequential analysis of design processes performed by design experts and college students in infographic design</td>
</tr>
<tr>
<td>Investigator:</td>
<td>Renata Kuba Kamikabeya</td>
</tr>
<tr>
<td>Submission ID:</td>
<td>STUDY00003681</td>
</tr>
<tr>
<td>Study ID:</td>
<td>STUDY00003681</td>
</tr>
<tr>
<td>Funding:</td>
<td>None</td>
</tr>
<tr>
<td>Grant ID:</td>
<td>None</td>
</tr>
<tr>
<td>IND, IDE, or HDE:</td>
<td>None</td>
</tr>
<tr>
<td>Documents Reviewed:</td>
<td>• IRB_consent form.pdf, Category: Consent Form; • Sequential analysis of design processes performed by design experts and college students in infographic design, Category: IRB Protocol;</td>
</tr>
</tbody>
</table>

The IRB staff determined the protocol qualifies for exemption, and where applicable the IRB has determined that the protocol qualifies for approval in accordance with federal regulatory requirements for Limited IRB review, effective on 10/27/2022. Further IRB review and approval by this organization is not required.

COVID-19 Information for Research Involving Human Subjects: Note that the U.S. is operating under the national emergency Proclamation 9994 concerning the COVID-19 pandemic and that this national emergency remains in effect until rescinded or terminated by the President of the U.S. (go here for the Proclamation letter). Conditions are dynamic and related policies or guidance evolve accordingly; as applicable, refer to the U.S. Centers for Disease Control and Prevention website specific for universities or refer to our COVID-19 and Human Research Studies web page to learn more about how you should or may protect persons (whether vaccinated or unvaccinated) involved in any of your in-person research activities.

Other Information:
You are advised that any modification(s) to the protocol for this project that may alter this exemption determination must be reviewed and approved prior to implementation of the proposed modification(s).

Modifications to the research may invalidate the exemption determination (because the research no longer meets the exemption criteria described in HRP-312 – WORKSHEET – Exemption Determination).

Examples of minor changes to exempt research that would not alter the exemption determination and should therefore not be submitted to the IRB for further review include the following:

• Making administrative (formatting, grammar, spelling) revisions to the protocol, consent or recruitment materials or other study documents
• Adding or revising non-sensitive questions or non-identifiable response options to a survey, interview, focus group or other data collection instrument
• Increasing or decreasing the number of study subjects—unless adding a new study sample such as children or prisoners or adding a new source of data or records
• Making study team/personnel changes—except (1) a change in Principal Investigator (PI) or (2) a change in other study personnel for whom regulatory approval of involvement in the study must be documented for purposes of institutional policy, sponsorship or funding, or other administrative purposes (e.g., graduation or manuscript clearance; addition of non-FSU study personnel).

Examples of changes to exempt research that do require prospectively submitting a modification to the IRB before implementing changes include the following:

• Making substantive revisions or additions (e.g., change in PI; funding source; sample; source of study subjects or their data; study sites or settings; procedures, interventions or interactions with study subjects; use of any drug, device, supplement or biologic; study subjects’ time or duration spent performing or participating in study activities) to the protocol, consent or recruitment materials or other study documents
• Adding or revising sensitive questions or identifiable response options to a survey, interview, focus group or other data collection instrument
• Adding a new study sample such as children or prisoners or adding a new source of data or records
• Obtaining, using, studying, analyzing, generating, storing or maintaining identifiable information or identifiable biospecimens in addition to or in lieu of de-identified or anonymous information or specimens
• Change in study risks (e.g., impact upon study subjects; impact upon students’ opportunity to learn educational content or assessment of educators who provide instruction; any disclosure of study subjects’ responses outside of the research may place study subjects at risk of criminal or civil liability or be damaging to subjects’ financial standing, employability, educational advancement or reputation)
• Change in Principal Investigator (PI) or (for students) faculty advisor
• Any involvement of a non-FSU institution or organization
• New or change in financial interest

In conducting this protocol, you are required to follow the applicable requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the Library within the RAMP IRB system.

Sincerely,
Office for Human Subjects Protection (OHSP) Florida State
University Office of Research 2010 Levy Avenue, Building B
Suite 276 Tallahassee, FL 32306-2742
Phone: 850-644-7900
Email: humansubjects@fsu.edu OHSP Web:
https://ohsp.fsu.edu
APPENDIX F
CONSENT FORM

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Title of the Study: Sequential analysis of design processes performed by design experts and college students in infographic design

Principal Investigator: Renata Kuba, Ph.D. Candidate at FSU

Faculty Advisor: Allan Jeong, Associate Professor in Instructional Systems & Learning Technologies

Introduction
You are being invited to volunteer to take part in our research study. It is up to you whether you choose to take part or not. There will be no penalty or loss of benefits to you if you choose not to take part or decide later not to take part. Please find below information about this research for you to think about before you decide to take part. Ask us if you have any questions about this information or the research before you decide to take part.

Why is this study being done?
This study is being conducted by Renata Kuba from the Educational Psychology & Learning System department at Florida State University. The reason that we are doing this research is to find ways to improve visual communication skills. For this research, we would like to observe your design process while creating an infographic and assess your generated infographic.

Duration
We think that taking part in our study will last approximately 70 minutes.

Research Activities
If you agree to participate in this study, we would ask you to do the following: at the beginning of the session, you will be asked some questions regarding your educational background, professional experience, and familiarity with visual design projects. The questions will take place orally. Next, you will be asked to read a material and answer a multiple-choice test about the material. Then, the main part of the research is when you will design an infographic while verbalizing your thoughts throughout the design task. The goal is to create a readable and visual appealing infographic. The session will be recorded (both audio and video screen) and your participation in the research is completely voluntary.

Risks
There is minimal anticipated risk for participating in this research. The research has the same amount of risk as is encountered during a usual online activity.
CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Benefits
There are no direct benefits to participation in this study. Indirect benefits may include learning about visual design principles and practicing visual communication skills.

What is this study about?
Researchers at Florida State University are studying ways to improve visual communication skills. Researchers are interested in finding out the differences between how designers apply visual design principles in designing infographics. You are invited to take part in the study because you are from the target population we are interested in – college students or graphic designers. Your input is very important to us. You are one of the 10 people to take part in this study. Your involvement in the study is expected to last 70 minutes.

What will you do to protect my privacy?
The results of the study may be published or presented, but no information that may identify you will ever be provided or released in publications or presentations. We will take steps to protect your privacy and confidentiality. Despite taking steps to protect your privacy or the confidentiality of your identifiable information, we cannot guarantee that your privacy or confidentiality will be protected. For example, if you tell us something that makes us believe that you or others have been or may be physically harmed, we may need to report that information to the appropriate agencies. Individuals and organizations responsible for conducting or monitoring this research may be permitted access to and inspect the research records. This includes the Florida State University Institutional Review Board (FSU IRB), which reviewed this study.

Confidentiality
The records of this study will be kept private and confidential, to the extent allowed by law. In any publications or presentations, we will not include any information that will make it possible to identify you as a subject. To ensure confidentiality, no names will be entered into a database. Your anonymity will be protected to the extent allowed by law. All data will be destroyed after 5 years.

What is the compensation for the research?
If you agree to take part in this research study and complete the entire session from start to end, you will be provided with a gift card of $15 delivered online and within 10 business days after the session for your time and effort.

What will happen if I choose not to participate?
It is your choice to participate or not to participate in this research. Participation is voluntary.
CONSENT TO PARTICIPATE IN A RESEARCH STUDY

You do not have to take part in this study, but if you do, you can stop at any time. Your decision whether to participate will not affect your relationship with the researchers. There are no penalty/consequences/loss of benefits to which you are otherwise entitled, if you do not participate.

You have the right to choose not to participate in any study activity or completely withdraw from continued participation at any point in this study without penalty/consequences/loss of benefits to which you are otherwise entitled.

If you withdraw from the study, the data collected to the point of withdrawal will be deleted.

Who do I talk to if I have questions?
If you have questions, concerns, or have experienced a research-related injury, contact the research at:

   Renata Kuba Kamikabeya, Ph.D. student at FSU
   (850) 339-8408
   Rk18d@my.fsu.edu

The Florida State University Institutional Review Board (“IRB”) is overseeing this research. The FSU IRB is a group of people who perform official independent review of research studies before studies begin to ensure that the rights and welfare of participants are protected. If you have questions about your rights or wish to speak with someone other than the research team, you may contact:

   Florida State University IRB
   2010 Levy Drive, Suite 276
   Tallahassee, Florida 32306
   850-644-7900
   humansubjects@fsu.edu
CONSENT TO PARTICIPATE IN A RESEARCH STUDY

STATEMENT OF CONSENT
I have read and considered the information presented in this form. I confirm that I understand the purpose of the research and the study procedures. I understand that I may ask questions at any time and can withdraw my participation without prejudice. I have read this consent form. My signature below indicates my willingness to participate in this study.

I consent to participate in this study.

____________________________
Printed Name of Adult Participant

____________________________   __________________
Signature of Adult Participant   Date

I agree to be audiotaped
YES (initial) ____   NO (initial) ____

I agree to be videotaped
YES (initial) ____   NO (initial) ____

Researcher’s Signature
I have fully explained the research study described by this form. I have answered the participant and/or parent/guardians’ questions and will answer any future questions to the best of my ability. I will tell the family and/or the person taking part in this research of any changes in the procedures or in the possible harms/possible benefits of the study that may affect their health or their willingness to stay in the study.

____________________________
Printed Name of Research Team Member Obtaining Consent

____________________________   __________________
Signature of Research Team Member   Date

Page 4 of 4
APPENDIX G
PERMISSION TO USE FIGURES

Ynt: Permission to use figures

PINAR NUHOĞLU KİBAR
Wed 10/26/2022 6:30 AM
To: Renata Kuba <rkamikabeya@fsu.edu>

Hi Renata,

Happy to hear that you focused on infographics in your dissertation. You can use model and process images and also IDR in your thesis by giving reference to the related paper.

I’d like to share my last book chapter in which I’ve revised the model visuals. May be you’ll find them meaningful too.


https://www.igi-global.com/chapter/making-good-use-of-pictures/275562

Good luck with your dissertation. If you have any questions about infographics, I'll be happy to discuss.

Regards,
Pınar

---

Gönderen: Renata Kuba <rkamikabeya@fsu.edu>
Gönderildi: 25 Ekim 2022 Salı 18:59:04
Kime: PINAR NUHOĞLU KİBAR
Konu: Permission to use figures

Hi Dr. Kibar,

How are you doing?
I hope all is well.
I’m writing to request permission to use the Infographic Design Model and Infographic Design Process images and the Infographic Design Rubric in my dissertation. I recreated and cited the figures and adapted the rubric, but I would like to show proof of permission to the manuscript clearance department. So, may I please use the figures and rubric in my dissertation?

Thanks,
Renata Kuba
Re: Permission to use figure

Richard Mayer
Tue 10/25/2022 12:14 PM
To: Renata Kuba <rkamikabeya@fsu.edu>
You have my version to use the figure in your dissertation. Best wishes, Richard Mayer

On Oct 25, 2022, at 9:01 AM, Renata Kuba <rkamikabeya@fsu.edu> wrote:

Hi Dr. Mayer,
How are you doing?
I hope all is well.
I'm writing to request permission to use the Cognitive Theory of Multimedia Learning image in my dissertation. I recreated and cited it, but I would like to show proof of permission to the manuscript clearance department. So, may I please use the Cognitive Theory of Multimedia Learning figure in my dissertation?
Thanks,
Renata Kuba

Richard E. Mayer
Distinguished Professor
Department of Psychological and Brain Sciences
University of California
Santa Barbara, CA 93106
REFERENCES


115


BIOGRAPHICAL SKETCH
RENATA KUBA

EDUCATIONAL BACKGROUND

2018-2023  Florida State University, Florida, USA
            Doctor of Philosophy
            Major: Instructional Systems and Learning Technologies
            Dissertation: *Sequential analysis of design processes performed by
design experts and college students in infographic design*

2014–2016  New York University, New York, USA
            Master of Professional Studies
            Major: Interactive Telecommunication

2012–2014  Claretiano University, Brasília, Brazil
            Bachelor's Degree
            Major: Arts

2010–2012  Senac University, Sao Paulo, Brazil
            Postgraduate Degree
            Major: Editorial Design

2006–2009  Senac University, Sao Paulo, Brazil
            Bachelor's Degree
            Major: Visual Communication

Certificates  Instructional Design, 2012, São Caetano University

PROFESSIONAL EXPERIENCES

2023–present  Senior Digital Content Specialist, Boston Scientific (USA)

2012–2022  Learning Experience Consultant
            Clients: Younder, FTD, Change by Design, among others.

2011–2022  UX/UI Design Consultant
            Clients: FTD, Tecnowise, EVA, among others.
2016–2022  Senior UX/UI and Instructional Designer, Tecnowise (SP, Brazil)
2012–2014  Instructional Design Lead, São Caetano University (SP, Brazil)
2009–2011  Graphic Designer, Signorini Graphic Production (SP, Brazil)
2007–2009  Graphic Designer, Texto&Arte (SP, Brazil)

ACADEMIC EXPERIENCES

2018–2022  Research Assistant, Florida State University
           Project: Game-based Assessment and Support of STEM-related Competencies
           (NSF award number #037988, PI: Dr. Valerie Shute)
           Project: Mathematical Learning via Architectural Design and Modeling Using
           Game-based Learning (NSF award number #1720533, PI: Dr. Fengfeng Ke)

2018–2023  Teaching Assistant, Florida State University
           EME6636– Change Management
           EME6415–Development of Computer Courseware
           EME6403–Design for Online Collaborative Learning
           EME5602–Design and Technology
           EME5457–Introduction to Distance Learning
           EDF5442–Inquiry and Measurement for Practitioners

HONORS AND AWARDS

2022  Winner, Liliana Muhlman Masoner Memorial Scholarship
2018  2nd place, FSU Portfolio Contest, sponsored by Enterprise
2016  1st place, Graphic Designer, Osasco Town Hall (over 800 applicants)
2016  Times Electronic Square Garden (art installation) – New York, NY
2014  2nd place, Visual Programmer, São Paulo Virtual University
2014  Brazilian Scientific Program (received $40,000 academic scholarship)
2012  2nd place, Visual Programmer, University of ABC
2011  1st place, Instructional Designer, São Caetano University
2009  Exhibition at Spielwarenmesse International Toy – Nuremberg, Germany
      (project: educational game Tribo das Palavras)
2009  Exhibition at ABRIN, the largest toy fair in Latin America – Brazil
      (project: educational game Tribo das Palavras)
2009  Tribo das Palavras was bought by Estrela and sold nationwide in Brazil
2008  1st place, Brazil’s National Game Design Competition with the educational
      game Tribo das Palavras

INVITED TALK

Kuba, R. (2022, October). *Presentation matters: Basics of graphic design in educational
technology*. Online talk given at Western Illinois University, Macomb, IL.

Kuba, R. (2021, July). *Data analytics in educational technology research*. Online talk given at
Florida A&M University, Tallahassee, FL.

Kuba, R. (2021, February). *Graphic design basics*. Online talk given at
FSU Environmental Health & Safety, Tallahassee, FL.

Kuba, R. (2021, February). *Visual design for instructional designers*. Online talk given at
Western Illinois University, Macomb, IL.

Western Illinois University, Macomb, IL.

the Juventude PL workshop, SP, Brazil.

PUBLICATIONS
JOURNAL ARTICLES AND BOOK CHAPTERS

**Kuba, R.** (abstract accepted). Using visual communication skills to succeed in your instructional design career. In R. E. West, & H. Leary (Eds.), *Becoming an LIDT Professional.* EdTech Books.


https://doi.org/10.1007/s40593-020-00196-1

**REFEREED CONFERENCE PROCEEDINGS**


**REFEREED CONFERENCE PAPERS**


Kuba, R., & Jeong, A. (2021, November). *Exploring how designers apply visual design principles to create visual composition for instructional infographics.* Paper under review for the Association of Educational Communications and Technology International Conference, Columbus, OH.


PROFESSIONAL MEMBERSHIPS

American Educational Research Association, 2020–Present
Association for Educational Communications and Technology, 2019–Present

SCHOLARLY JOURNAL REVIEWER

2021–present  Journal of Information Technology Education (Gold Reviewer 2021)
2021–present  Journal of Research on Technology in Education
2021–present  Turkish Online Journal of Educational Technology
2021–present  SN Computer Science Journal
2021–present  The Design Principles and Practices Journal
2021–present  Journal of Technology and Teacher Education
2021–present  The Learner Journal Collection
2020–present  The Internet and Higher Education Journal